



HIRSCHMANN

A **BELDEN** BRAND

User Manual

Redundancy Configuration

Industrial ETHERNET (Gigabit) Switch

RS20/RS30/RS40, MS20/MS30, OCTOPUS

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About this Manual

The “Redundancy Configuration” user manual contains all the information you need to select a suitable redundancy procedure and configure it.

The “Basic Configuration” user manual contains all the information you need to start operating the device. It takes you step by step from the first startup operation through to the basic settings for operation in your environment.

The “Installation” user manual contains a device description, safety instructions, a description of the display, and all the other information that you need to install the device before you begin with the configuration of the device.

The “Industry Protocols” user manual describes how the device is connected by means of a communication protocol commonly used in the industry, such as EtherNet/IP and PROFINET.

The "Web-based Interface" reference manual contains detailed information on using the Web interface to operate the individual functions of the device.






The "Command Line Interface" reference manual contains detailed information on using the Command Line Interface to operate the individual functions of the device.

The Network Management Software HiVision/Industrial HiVision provides you with additional options for smooth configuration and monitoring:







- ▶ Configuration of multiple devices simultaneously.
- ▶ Graphical interface with network layouts.
- ▶ Auto-topology discovery.
- ▶ Event log.
- ▶ Event handling.
- ▶ Client / Server structure.
- ▶ Browser interface
- ▶ ActiveX control for SCADA integration
- ▶ SNMP/OPC gateway

Key

The designations used in this manual have the following meanings:

	List
	Work step
	Subheading
Link	Indicates a cross-reference with a stored link
Note:	A note emphasizes an important fact or draws your attention to a dependency.
<code>Courier</code>	ASCII representation in user interface
	Execution in the Web-based Interface user interface
	Execution in the Command Line Interface user interface

Symbols used:

	Router with firewall
	Switch with firewall
	Router
	Switch
	Bridge
	Hub

Key



A random computer



Configuration Computer



Server



PLC -
Programmable logic
controller



I/O -
Robot

1 Introduction

The device contains a range of redundancy functions:

- ▶ HIPER-Ring
- ▶ MRP-Ring
- ▶ Ring/Network Coupling
- ▶ Rapid Spanning Tree Algorithm (RSTP)

1.1 Overview of Redundancy Procedure

Redundancy procedure	Network topology	Switching time
RSTP	Random structure	typically < 1 s (STP < 30 s), up to < 30 s - depends heavily on the number of devices Note: Up to 79 devices possible, depending on topology and configuration. If the default values are being used, up to 39 devices are possible, depending on the topology (see page 53).
HIPER-Ring	Ring	typically 80 ms, up to < 500 ms - practically independently of the number of devices
MRP-Ring	Ring	typically 80 ms, up to < 500 ms - practically independently of the number of devices Note: In combination with RSTP in MRP compatibility mode, up to 39 devices are possible, depending on the configuration. If the default values for RSTP are being used, up to 19 devices are possible (see page 53).
Redundant coupling	Coupling of network segment/rings via a main line and a redundant line	typically 150 ms, up to < 500ms

Table 1: Comparison of the redundancy procedures

Note: Informations concerning the switching time you can find on the Hirschmann internet site (www.hirschmann-ac.com) at the end of the product site.

2 Ring Redundancy

The concept of ring redundancy allows the construction of high-availability, ring-shaped network structures.

With the help of the RM (**R**ing **M**anager) function, the two ends of a backbone in a line structure can be closed to a redundant ring. The ring manager keeps the redundant line open as long as the line structure is intact. If a segment fails, the ring manager immediately closes the redundant line, and line structure is intact again.

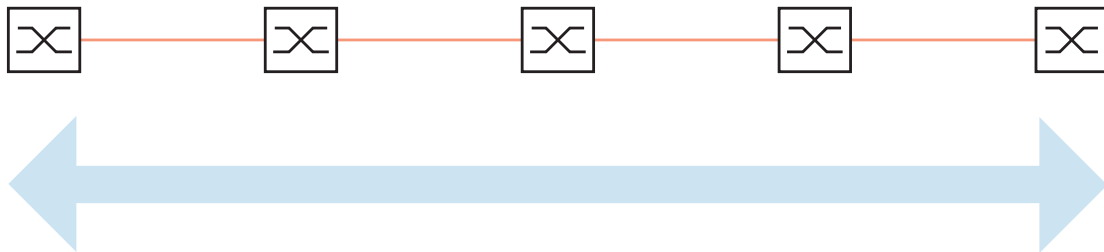


Figure 1: Line structure

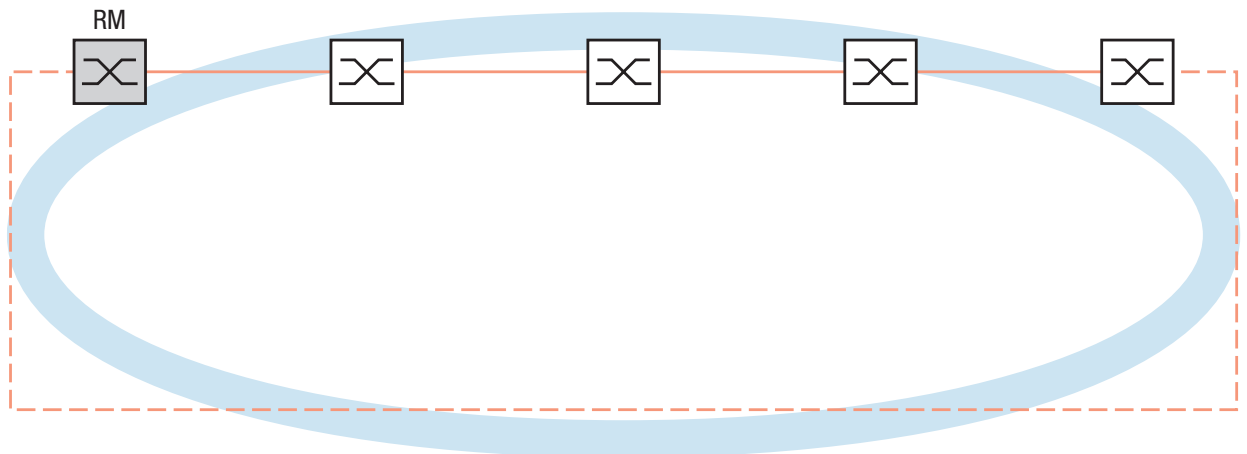


Figure 2: Redundant ring structure
RM = Ring Manager
— main line
- - - redundant line

If a section is down, the ring structure of a

- ▶ **HIPER-(HIGH PERFORMANCE REDUNDANCY)** Ring with up to 50 devices typically transforms back to a line structure within 80 ms (setting: standard/accelerated).
- ▶ **MRP (Media Redundancy Protocol)** Ring (IEC 62439) of up to 50 devices typically transforms back to a line structure within 80 ms (adjustable to max. 200 ms/500 ms).

Device requirements for using the HIPER-Ring function:

- ▶ Within a HIPER-Ring, you can use any combination of the following devices:
 - RS1
 - RS2-./.
 - RS2-16M
 - RS2-4R
 - RS20, RS30, RS40
 - RSR20, RSR30
 - OCTOPUS
 - MICE
 - MS20, MS30
 - Power MICE
 - MACH 100
 - MACH 1000
 - MACH 3000
 - MACH 4000
- ▶ Within an MRP-Ring, you can use devices that support the MRP protocol based on IEC62439.

Note: Enabled Ring Redundancy methods on a device are mutually exclusive at any one time. When changing to another Ring Redundancy method, deactivate the function for the time being.

Note: The following usage of the term “ring manager” instead of “redundancy manager” makes the function easier to understand.

2.1 Example of HIPER-Ring

A network contains a backbone in a line structure with 3 devices. To increase the redundancy reliability of the backbone, you have decided to convert the line structure to a HIPER-Ring. You use ports 1 and 2 in module 1 of the devices to connect the lines.

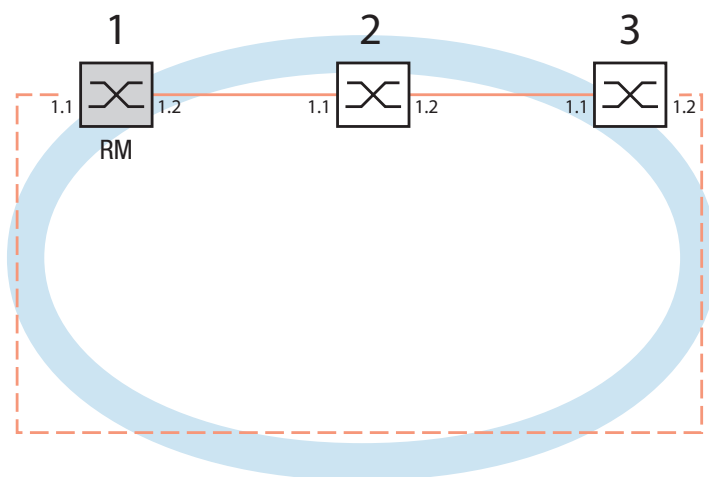


Figure 3: Example of HIPER-Ring

RM = Ring Manager

— main line

- - - redundant line

The following example configuration describes the configuration of the ring manager device (1). The two other devices (2 to 3) are configured in the same way, but without activating the ring manager function. Select the “Standard” value for the ring recovery, or leave the field empty.

Note: As an alternative to using software to configure the HIPER-Ring, with devices RS20/30/40 and MS20/30 you can also use a DIP switch to enter a number of settings. You can also use a DIP switch to enter a setting for whether the configuration via DIP switch or the configuration via software has priority. The state on delivery is “Software Configuration”.

Note: Configure all the devices of the HIPER-Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the HIPER-Ring. You thus avoid loops during the configuration phase.

2.1.1 Setting up and configuring the HIPER-Ring

- ☐ Set up the network to meet your requirements.
- ☐ You configure all 6 ports so that the transmission speed and the duplex settings of the lines correspond to the following table:

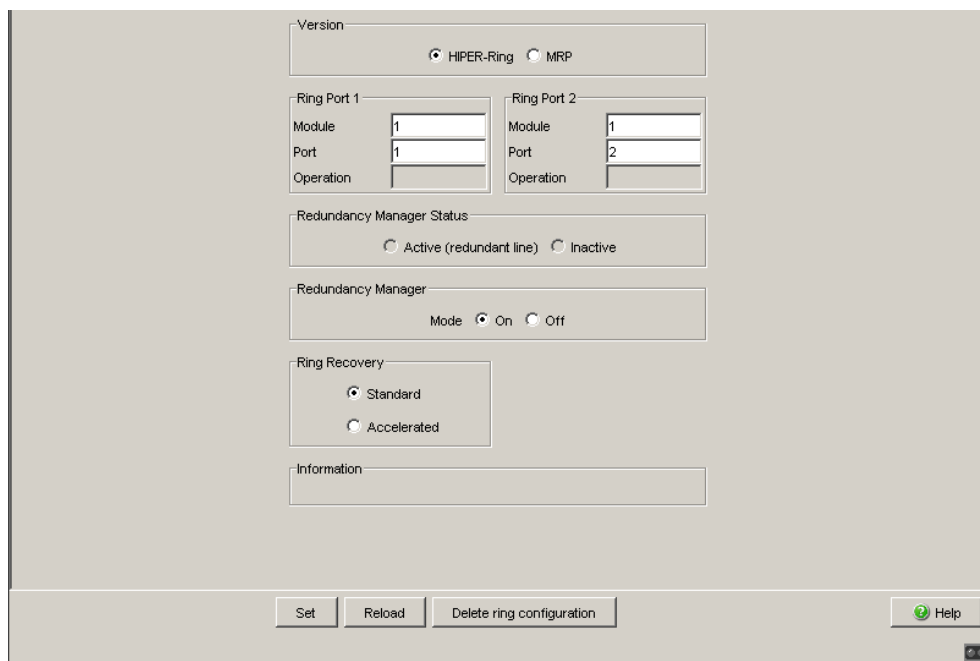
Bit rate	100 Mbit/s	1000 Mbit/s
Autonegotiation (automatic configuration)	off	on
Port	on	on
Duplex	Full	–

Table 2: Port settings for ring ports

- ☐ Select the `Redundancy:Ring Redundancy` dialog.
- ☐ Under “Version”, select `HIPER-Ring`.
- ☐ Define the desired ring ports 1 and 2 by making the corresponding entries in the module and port fields. If it is not possible to enter a module, then there is only one module in the device that is taken over as a default.

Display in “Operation” field:

- active: This port is switched on and has a link.
- inactive: This port is switched off or it has no link.



The image shows a 'Ring Redundancy' configuration dialog box. It has a title bar and a main content area with several sections. At the top, there's a 'Version' section with two radio buttons: 'HIPER-Ring' (selected) and 'MRP'. Below this are two columns for 'Ring Port 1' and 'Ring Port 2'. Each column has three input fields: 'Module' (both set to '1'), 'Port' (set to '1' for Port 1 and '2' for Port 2), and 'Operation' (both empty). Underneath is a 'Redundancy Manager Status' section with two radio buttons: 'Active (redundant line)' (selected) and 'Inactive'. This is followed by a 'Redundancy Manager' section with a 'Mode' label and two radio buttons: 'On' (selected) and 'Off'. Below that is a 'Ring Recovery' section with two radio buttons: 'Standard' (selected) and 'Accelerated'. At the bottom of the main area is an 'Information' section with a large empty text box. At the very bottom of the dialog are four buttons: 'Set', 'Reload', 'Delete ring configuration', and 'Help' (with a green question mark icon).

Figure 4: Ring Redundancy dialog

- ☐ Activate the ring manager for this device. Do not activate the ring manager for any other device in the HIPER-Ring.
 - ☐ In the “Ring Recovery” frame, select the value “Standard” (default).
- Note:** Settings in the “Ring Recovery” frame are only effective for devices that you have configured as ring managers.
- ☐ Click on “Set” to temporarily save the entry in the configuration.


```

enable                               Switch to the Privileged EXEC mode.
configure                           Switch to the Configuration mode.
hiper-ring mode ring-manager        Select the HIPER-Ring ring redundancy and de-
                                     fine the device as ring manager.

Switch's HIPER Ring mode set to ring-manager
hiper-ring port primary 1/1         Define port 1 in module 1 as ring port 1.
HIPER Ring primary port set to 1/1
hiper-ring port secondary 1/2       Define port 2 in module 1 as ring port 2.
HIPER Ring secondary port set to 1/2
exit                                Switch to the privileged EXEC mode.
show hiper-ring                     Display the HIPER-Ring parameters.
HIPER Ring Mode of the Switch..... ring-manager
configuration determined by..... management
HIPER Ring Primary Port of the Switch..... 1/1, state active
HIPER Ring Secondary Port of the Switch..... 1/2, state active
HIPER Ring Redundancy Manager State..... active
HIPER Ring Redundancy State (red. guaranteed).. no (rm is active)
HIPER Ring Setup Info (Config. failure)..... no error
HIPER Ring Recovery Delay..... 500ms

```

☐ Now proceed in the same way for the other two devices.

Note: If you have configured VLANs, note the VLAN configuration of the ring ports.

In the configuration of the HIPER-Ring, you select for the ring ports

- VLAN ID 1 and
- VLAN membership Untagged in the static VLAN table

Note: Deactivate the Spanning Tree protocol on the ports connected to the HIPER-Ring because Spanning Tree and Ring Redundancy affect each other. If you enable the HIPER-Ring function by means of the DIP switch, RSTP will be disabled automatically.

☐ Now you connect the line to the ring. To do this, you connect the two devices to the ends of the line using their ring ports.

The displays in the “Redundancy Manager Status” frame mean:

- “Active (redundant line)”: The ring is open, which means that a data line or a network component within the ring is down.
- “Inactive”: The ring is closed, which means that the data lines and network components are working.

The displays in the “Information” frame mean

- “Redundancy existing”: One of the lines affected by the function can fail, whereby the redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incorrectly configured or there is an error in the ring port connection.

Note: When you use the DIP switch to switch from a normal port to a ring port, the device makes the required settings for the pre-defined ring ports in the configuration table. The port which has been switched back from a ring port to a normal port keeps the ring port settings (transmission speed and mode). Independently of the DIP switch setting, you can still change all the ports via the software.

2.2 Example of MRP-Ring

A network contains a backbone in a line structure with 3 devices. To increase the redundancy reliability of the backbone, you have decided to convert the line structure to a ring redundancy. In contrast to the previous example, devices from different manufacturers are being used which do not all support the HIPER-Ring protocol. All the devices have MRP as the ring redundancy protocol, so you decide to use MRP. You use ports 1 and 2 in module 1 of the devices to connect the lines.

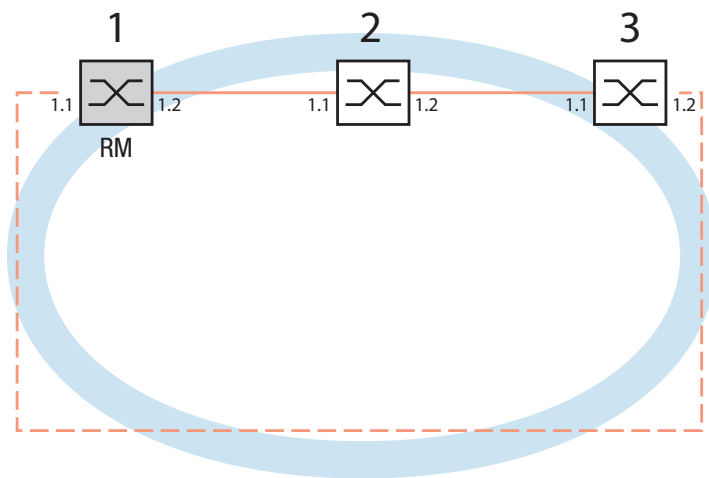


Figure 5: Example of MRP-Ring
RM = Ring Manager
— *main line*
- - - *redundant line*

The following example configuration describes the configuration of the ring manager device (1). You configure the two other devices (2 to 3) in the same way, but without activating the ring manager function. This example does not use a VLAN. You have entered 200 ms as the ring recovery time, and all the devices support the advanced mode of the ring manager.

Note: Configure all the devices of the MRP-Ring individually. Before you connect the redundant line, you must complete the configuration of all the devices of the MRP-Ring. You thus avoid loops during the configuration phase.

- ☐ Set up the network to meet your requirements.
- ☐ You configure all 6 ports so that the transmission speed and the duplex settings of the lines correspond to the following table:

Bit rate	100 Mbit/s	1000 Mbit/s
Autonegotiation (automatic configuration)	off	on
Port	on	on
Duplex	Full	–

Table 3: Port settings for ring ports

- ☐ Select the `Redundancy:Ring Redundancy` dialog.
- ☐ Under “Version”, select `MRP`.
- ☐ Define the desired ring ports 1 and 2 by making the corresponding entries in the module and port fields. If it is not possible to enter a module, then there is only one module in the device that is taken over as a default.

Display in “Operation” field:

forwarding: this port is switched on and has a link.

blocked: this port is blocked and has a link.

disabled: this port is switched off

not connected: this port has no link.

The image shows a 'Ring Redundancy' configuration dialog box. It contains several sections for configuring network redundancy. The 'Version' section has radio buttons for 'HIPER-Ring' and 'MRP'. The 'Ring Port 1' and 'Ring Port 2' sections each have fields for 'Module', 'Port', and 'Operation'. The 'Configuration Redundancy Manager' section has a checkbox for 'Advanced Mode'. The 'Redundancy Manager' section has a 'Mode' section with radio buttons for 'On' and 'Off'. The 'Operation' section has radio buttons for 'On' and 'Off'. The 'Ring Recovery' section has radio buttons for '500ms' and '200ms'. The 'VLAN' section has a 'VLAN ID' field. The 'Information' section is at the bottom. At the bottom of the dialog are buttons for 'Set', 'Reload', 'Delete ring configuration', and 'Help'.

Figure 6: Ring Redundancy dialog

- ☐ In the “Ring Recovery” frame, select 200ms.

Note: If selecting 200ms for the ring recovery does not provide the ring stability necessary to meet the requirements of your network, you select 500ms.

Note: Settings in the “Ring Recovery” frame are only effective for devices that you have configured as ring managers.

- ☐ Under “Configuration Redundancy Manager”, activate the advanced mode.
- ☐ Activate the ring manager for this device. Do not activate the ring manager for any other device in the MRP-Ring.
- ☐ Leave the VLAN ID as 0 in the VLAN field.
- ☐ Switch the operation of the MRP-Ring on.
- ☐ Click on “Set” to temporarily save the entry in the configuration.

The displays in the “Information” frame mean

- “Redundancy existing”: One of the lines affected by the function can fail, whereby the redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incorrectly configured or there is an error in the ring port connection.

The “VLAN” frame enables you to assign the MRP-Ring to a VLAN:

- If VLANs are configured, you make the following selections in the “VLAN” frame:
 - VLAN ID 0, if the MRP-Ring configuration is not to be assigned to a VLAN, as in this example.
Note the VLAN configuration of the ring ports. Select VLAN ID 1 and VLAN membership Untagged in the static VLAN table for the ring ports.
 - a VLAN ID >0, if the MRP-Ring configuration is to be assigned to this VLAN.
Enter this VLAN ID in the MRP-Ring configuration for all devices in this MRP-Ring.
Note the VLAN configuration of the ring ports. For all ring ports in this MRP-Ring, select this VLAN ID and the VLAN membership Tagged in the static VLAN table.

Note: For all devices in an MRP-Ring, activate the MRP compatibility in the `Rapid Spanning Tree:Global` dialog if you want to use RSTP in the MRP-Ring. If this is not possible, perhaps because individual devices do not support the MRP compatibility, you deactivate the Spanning Tree protocol at the ports connected to the MRP-Ring. Spanning Tree and Ring Redundancy affect each other.

Note: If you want to configure an MRP-Ring using the Command Line Interface, you must define an additional parameter. When configured using CLI, an MRP-Ring is addressed via its MRP domain ID. The MRP domain ID is a sequence of 16 number blocks (8-bit values). Use the default domain of 255 255 255 255 255 255 255 255 255 255 255 255 255 255 255 for the MRP domain ID.

This default domain is also used internally for a configuration via the Web-based interface.

Configure all the devices within an MRP-Ring with the same MRP domain ID.

```
enable
```

```
configure
```

```
mrp new-domain default domain
```

Switch to the Privileged EXEC mode.

Switch to the Configuration mode.

Create a new MRP-Ring with the default domain ID

```
255,255,255,255,255,255,255,255,255,255,255,255,255,255,255,255.
```

```

MRP domain created:
Domain ID:
255.255.255.255.255.255.255.255.255.255.255.255.255
(Default MRP domain)

mrp current-domain          Define port 1 in module 1 as ring port 1 (primary).
port primary 1/1

Primary Port set to 1/1

mrp current-domain          Define port 2 in module 1 as ring port 2 (second-
port secondary 1/2          ary).

Secondary Port set to 1/2

mrp current-domain mode     Define this device as the ring manager.
manager

Mode of Switch set to Manager

mrp current-domain recovery- Define 200ms as the value for the "Ring Recov-
delay 200ms                 ery".

Recovery delay set to 200ms

mrp current-domain advanced- Activate the "MRP Advanced Mode".
mode enable

Advanced Mode (react on link change) set to Enabled

mrp current-domain operation enable Activate the MRP-Ring.

Operation set to Enabled

exit                        Go back one level.

show mrp                   Show the current parameters of the MRP-Ring
                           (abbreviated display).

Domain ID:
255.255.255.255.255.255.255.255.255.255.255.255.255
(Default MRP domain)

Configuration Settings:
Advanced Mode (react on link change).... Enabled
Manager Priority..... 32768
Mode of Switch (administrative setting). Manager
Mode of Switch (real operating state)... Manager
Domain Name..... <empty>
Recovery delay..... 200ms
Port Number, Primary..... 1/1, State: Not Connected
Port Number, Secondary..... 1/2, State: Not Connected
VLAN ID..... 0 (No VLAN)
Operation..... Enabled

```

- ☐ Now you connect the line to the ring. To do this, you connect the two devices to the ends of the line using their ring ports.

3 Ring/Network coupling

This device allows the redundant coupling of redundant rings and network segments. Two rings/network segments are connected via two separate paths.

The ring/network coupling supports the following devices:

- ▶ RS2-./.
- ▶ RS2-16M
- ▶ RS20, RS30, RS40
- ▶ OCTOPUS
- ▶ MICE (from rel. 3.0)
- ▶ Power MICE
- ▶ MS20, MS30
- ▶ RSR20, RSR30
- ▶ MACH 100
- ▶ MACH 1000
- ▶ MACH 3000 (from rel. 3.3),
- ▶ MACH 4000

3.1 Variants of the ring/network coupling

The redundant coupling is effected by the **one-Switch coupling** of two ports **of one** device in the first ring/network to one port each of two devices in a second ring/network segment ([see fig. 8](#)).

Immediately after the main line fails, the device opens the redundant line. When the main line is OK again, the main line is opened again and the redundant line is blocked again.

An error is detected and eliminated within 500 ms (typically 150 ms).

The redundant coupling is effected by the **two-Switch coupling** of one port each on **two** devices in the first ring/network to one port each of two devices in the second ring/network segment ([see fig. 14](#)).

The device in the redundant line and the device in the main line use control packets to inform each other about their operating states, via the Ethernet or the control line.

Immediately after the main line fails, the redundant device opens the redundant line. As soon as the main line is OK again, the device in the main line informs the redundant device. The main line is opened again, and the redundant line is blocked again.

An error is detected and eliminated within 500 ms (typically 150 ms).

The type of coupling primarily depends on the topological conditions and the desired level of safety ([see table 4](#)).

	One-Switch coupling	Two-Switch coupling	Two-Switch coupling with control line
Application	The two devices are in impractical topological positions. Therefore, putting a line between them would involve a lot of work for two-Switch coupling.	The two devices are in practical topological positions. Putting down a control line would involve a lot of work.	The two devices are in practical topological positions. Putting down a control line would not involve much work.
Disadvantage	If the Switch configured for the redundant coupling fails, no connection remains between the networks.	Much work involved in connecting the two devices to the network (compared with one-Switch coupling).	Much work involved in connecting the two devices to the network (compared with one-Switch and two-Switch coupling).
Advantage	Less work involved in connecting the two devices to the network (compared with two-Switch coupling).	If one of the devices configured for the redundant coupling fails, there is still a connection between the networks.	If one of the devices configured for the redundant coupling fails, there is still a connection between the networks.

Table 4: Selection criteria for the variants of the redundant coupling

Note: The choice of configuration primarily depends on the topological conditions and the desired level of security ([see table 4](#)).

3.2 Preparing a Ring/Network coupling

3.2.1 STAND-BY switch

The devices have a STAND-BY switch, with which you can define the role of the device within a Ring/Network coupling.

Depending on the device, this switch is a DIP switch or a software switch (Redundanz:Ring/Network Coupling dialog). By setting this switch, you define whether the device has the main coupling or the redundant coupling within a Ring/Network coupling.

Device type	STAND-BY switch type
RS2-./.	DIP switch
RS2-16M	DIP switch
RS20/RS30/RS40	Can be switched between DIP switch and software switch
MICE/Power MICE	Can be switched between DIP switch and software switch
MS20/MS30	Can be switched between DIP switch and software switch
OCTOPUS	Software switch
RSR20/RSR30	Software switch
MACH 100	Software switch
MACH 1000	Software switch
MACH 3000/MACH 4000	Software switch

Table 5: Overview of the STAND-BY switch types

Depending on the device and model, set the STAND-BY switch in accordance with the following table ([see table 6](#)):

Device with	Choice of main coupling or redundant coupling
DIP switch	On "STAND-BY" DIP switch
DIP switch/software switch option	<p>According to the option selected</p> <ul style="list-style-type: none"> - on "STAND-BY" DIP switch or in the - Redundancy:Ring/Network Coupling dialog, by making selection in "Select configuration". <p>Note: These devices have a DIP switch, with which you can choose between the software configuration and the DIP switch configuration. If you have set the software configuration, changing the other DIP switches has no effect.</p>
Software switch	In the Redundancy:Ring/Network Coupling dialog

Table 6: Setting the STAND-BY switch

- ☐ Select the Redundancy:Ring/Network Coupling dialog.
- ☐ You first select the configuration you want: One-Switch coupling ("1"), two-Switch coupling ("2") or two-Switch coupling with control line ("3"), (see fig. 7).

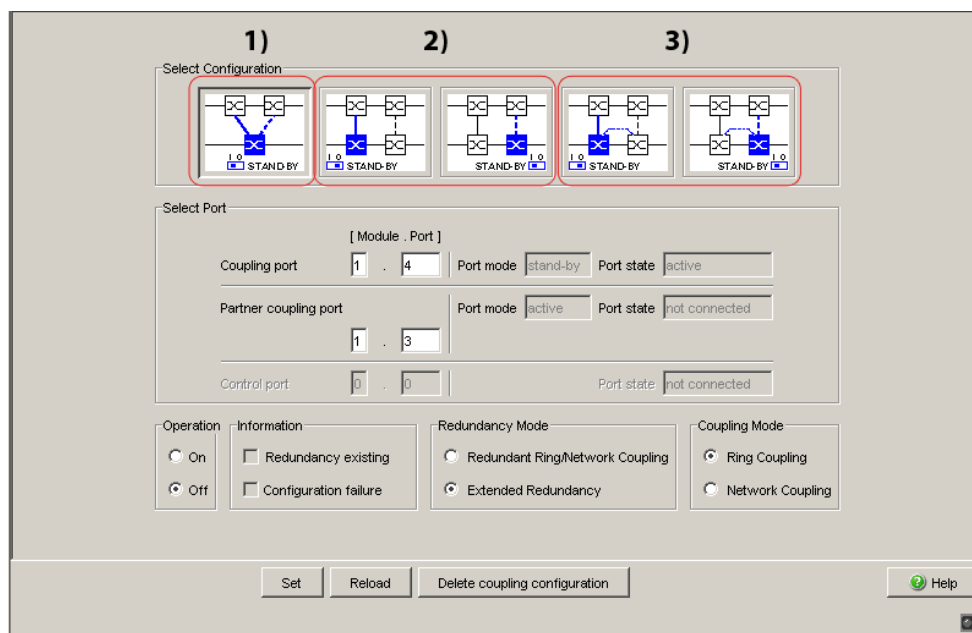


Figure 7: Selecting the configuration

Depending on the STAND-BY DIP switch position, the dialog displays those configurations that are not possible in gray. If you want to select one of these grayed-out configurations, you put the STAND-BY DIP switch on the Switch into the other position.

One-Switch coupling

Assign the device the DIP switch setting “STAND-BY”, or use the software configuration to assign the redundancy function to it.

Two-Switch coupling

Assign the device in the redundant line the DIP switch setting “STAND-BY”, or use the software configuration to assign the redundancy function to it.

Note: For redundancy security reasons, the combination of Rapid Spanning Tree and Ring/Network Coupling is not possible.

3.2.2 One-Switch coupling

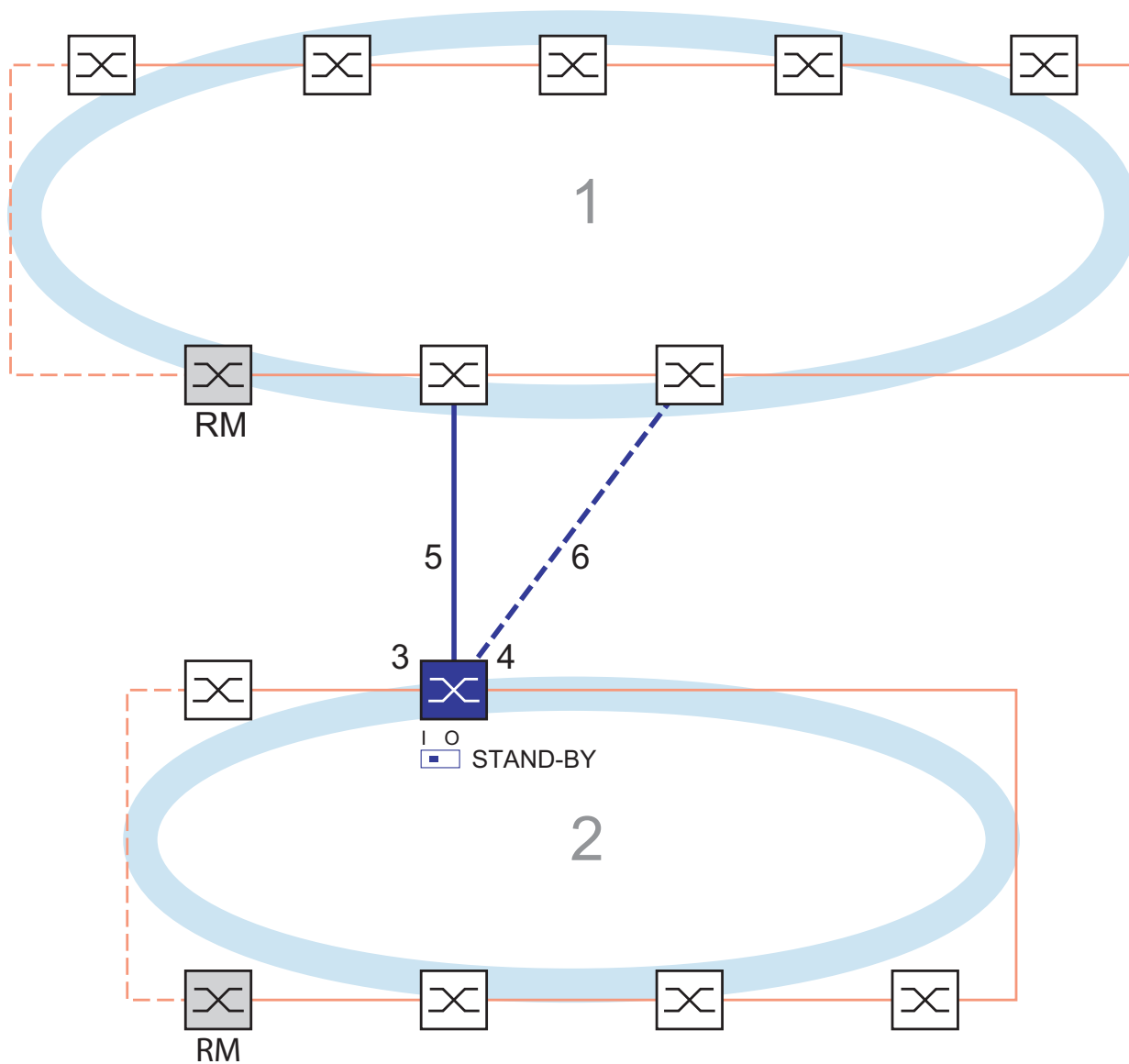


Figure 8: Example of one-Switch coupling

- 1: Backbone
- 2: Ring
- 3: Partner coupling port
- 4: Coupling port
- 5: Main Line
- 6: Redundant Line

The coupling between two networks is effected by the main line (thick blue line), which is connected to the partner coupling port. If the main line fails, the redundant line (thick blue dotted line), which is connected to the coupling port, takes over coupling the two networks. The coupling is effected by **one** Switch.

- ☐ Select the Redundancy:Ring/Network Coupling dialog.
- ☐ Select one-Switch coupling (see fig. 9).

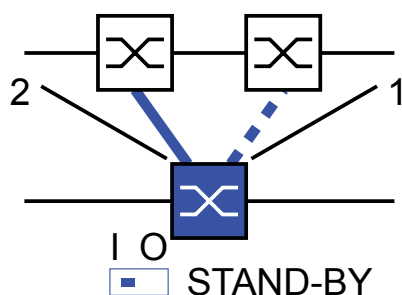


Figure 9: One-Switch-coupling
 1: Coupling port
 2: Partner coupling port

The following settings apply to the Switch displayed in blue in the selected graphic.

- ☐ Select the partner coupling port (see fig. 10), (see table 7).
 With "Partner coupling port" you specify at which port you are connecting the control line.

The following tables show the selection options and default settings for the ports used in the Ring/Network coupling.

Device	Partner coupling port	Coupling port
RS2-./.	Not possible	Not possible
RS2-16M	All ports (default setting: port 2)	All ports (default setting: port 1)
RS20, RS30, RS40	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
OCTOPUS	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MICE	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
Power MICE	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MS20	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MS30	All ports (default setting: port 2.3)	All ports (default setting: port 2.4)
RSR20/30	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MACH 100	All ports (default setting: port 2.3)	All ports (default setting: port 2.4)
MACH 1000	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)
MACH 3000	All ports	All ports
MACH 4000	All ports (default setting: port 1.3)	All ports (default setting: port 1.4)

Table 7: Port assignment for one-Switch coupling

Note: Configure the partner coupling port and the HIPER-Ring ports on different ports.

- ☐ Select the coupling port (see fig. 10), (see table 7).
With “Coupling port” you specify at which port you are connecting the redundant line.

Note: Configure the coupling port and the redundancy ring ports on different ports.

- ☐ Activate the function in the “Operation” frame (see fig. 16).
- ☐ You now connect the redundant line.

The displays in the “Select port” frame mean (see fig. 10):

- “Port mode”: The port is either active or in stand-by mode.
- “Port state”: The port is either connected or not connected.

The displays in the “Information” frame mean (see fig. 10):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

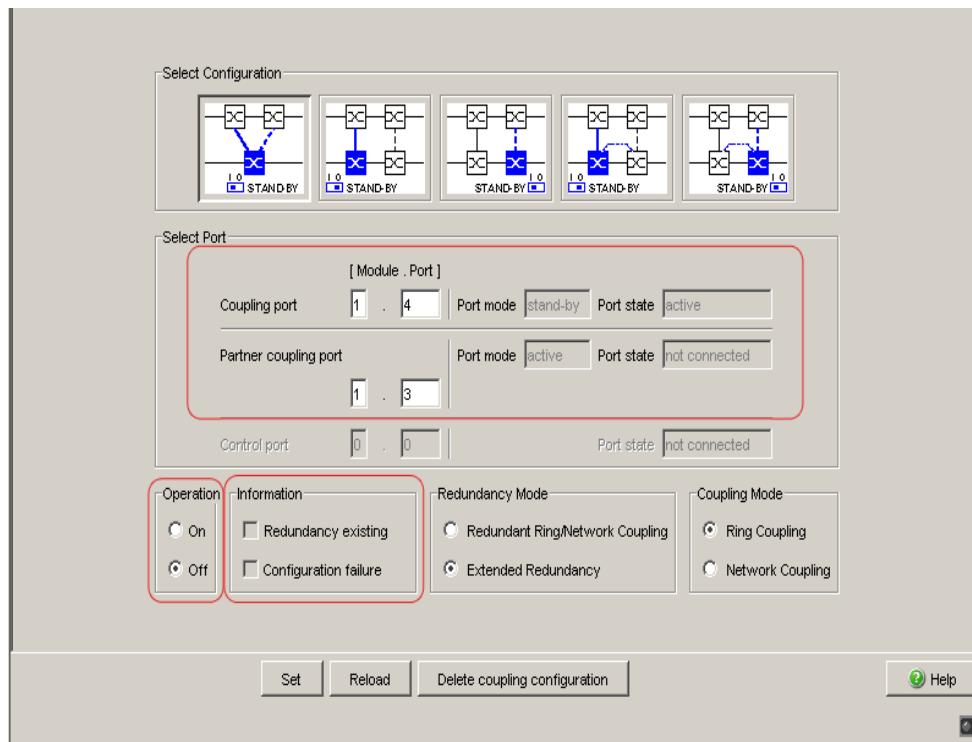


Figure 10: Selecting the port and enabling/disabling operation

Note: The following settings are required for the coupling ports (you select the Basic Settings:Port Configuration dialog):

- Port: on
- Automatic configuration (autonegotiation):
on for twisted-pair connections
- Manual configuration: 100 Mbit/s FDX
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership \cup in the static VLAN table.

Redundancy mode

- ☐ In the “Redundancy Mode” frame, select (see fig. 11)
 - “Redundant Ring/Network Coupling” or
 - “Extended Redundancy”.

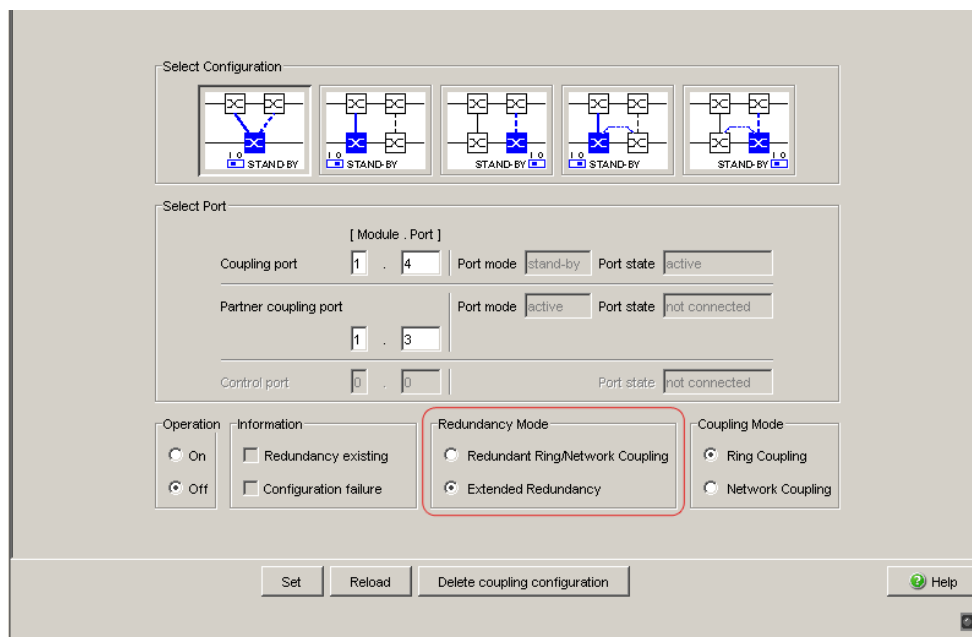


Figure 11: Selecting the redundancy mode

With the “Redundant Ring/Network Coupling” setting, either the main line or the redundant line is active. Both lines are never active simultaneously.

With the “Extended Redundancy” setting, the main line and the redundant line are simultaneously active if the connection line between the devices in the connected network fails (see fig. 12).

During the reconfiguration period, there may be package duplications. Therefore, only select this setting if your application detects package duplications.

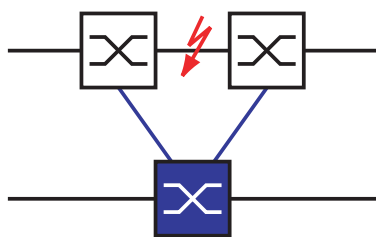


Figure 12: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

□ In the “Coupling Mode” frame, select (see fig. 13)

- “Ring Coupling” or
- “Network Coupling”

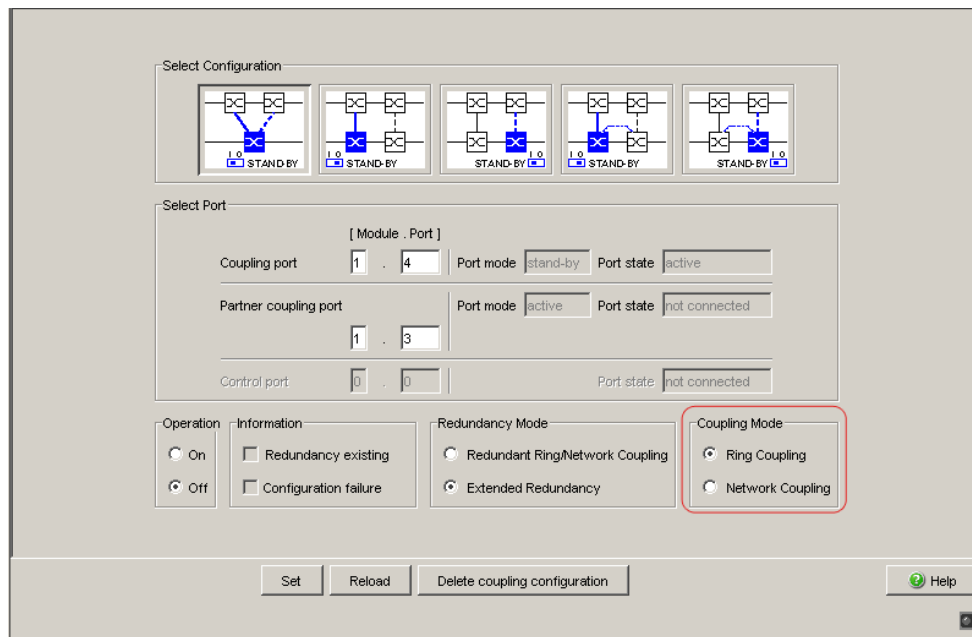


Figure 13: Selecting the coupling mode

- ☐ Select **“Ring coupling”** if you are connecting a redundancy ring.
- ☐ Select **“Network Coupling”** if you are connecting a line structure.

Delete coupling configuration

- ☐ The “Delete coupling configuration” button in the dialog allows you to reset all the coupling settings of the device to the state on delivery.

3.2.3 Two-Switch coupling

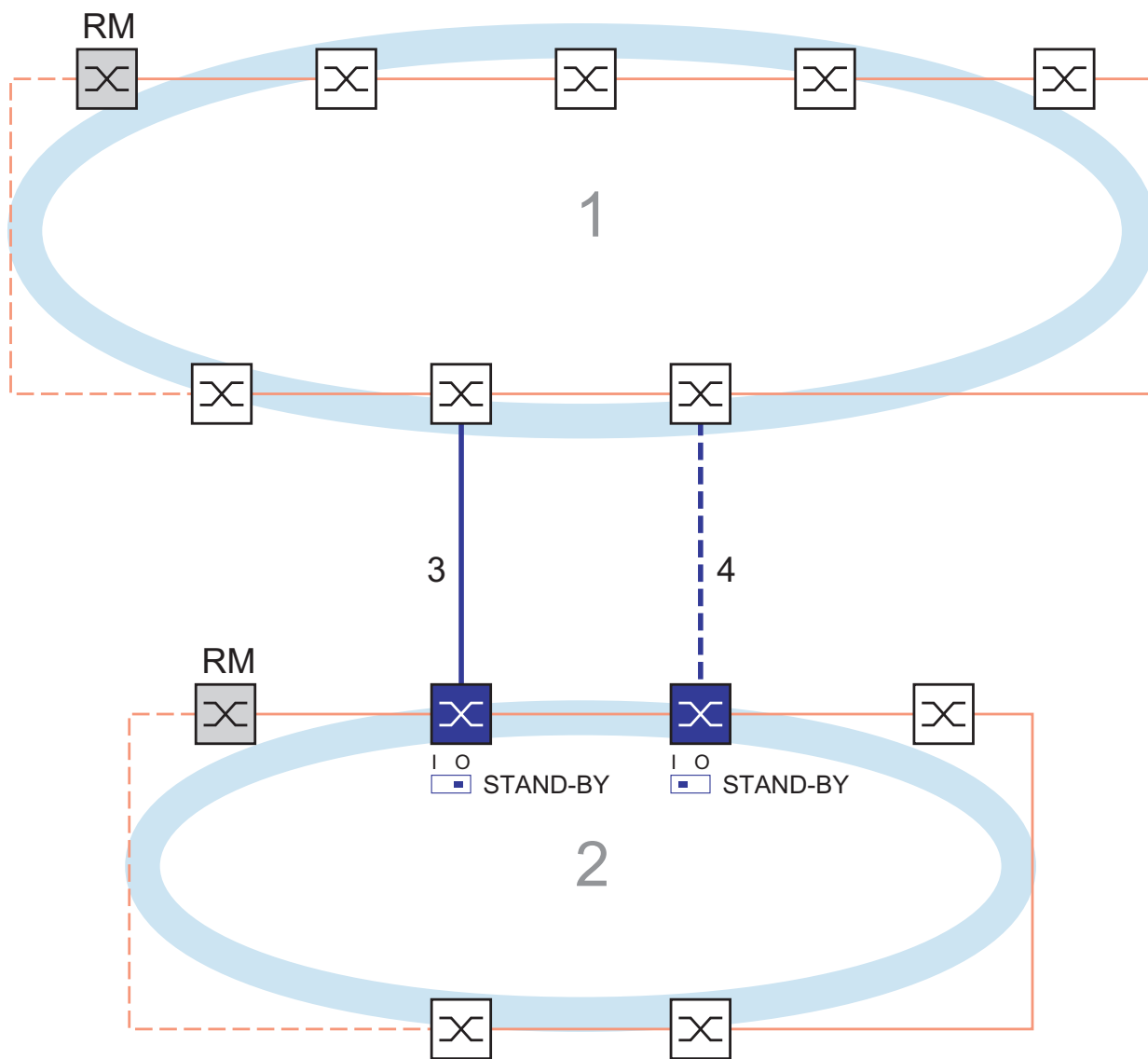


Figure 14: Example of two-Switch coupling

- 1: Backbone
- 2: Ring
- 3: Main line
- 4: Redundant line

The coupling between two networks is effected by the main line (thick blue line). If the main line fails, the redundant line (thick blue dotted line) takes over coupling the two networks.

The coupling is effected by two Switches.

The switches send their control packages via the Ethernet.

The Switch to which you connect the main line, and the Switch to which you connect the redundant line, are partners as regards the coupling.

- ☐ Connect the two partners via their ring ports.

- ☐ Select the Redundancy:Ring/Network Coupling dialog.
- ☐ Select two-Switch main coupling (see fig. 15).

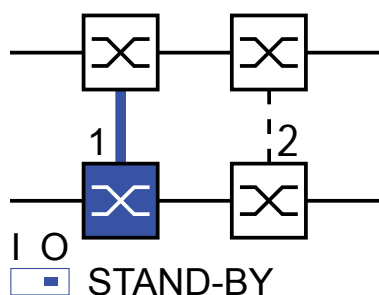


Figure 15: Two-Switch coupling

1: Coupling port

2: Partner coupling port

The following settings apply to the Switch displayed in blue in the selected graphic.

- ☐ Select the coupling port (see fig. 10), (see table 7).
With "Coupling port" you specify at which port you are connecting the redundant line.

- ☐ If the STANDBY DIP switch is OFF, connect the main line to the coupling port.

Device	Coupling port
RS2-./.	Not possible
RS2-16M	Adjustable for all ports (default setting: port 1)
RS20, RS30, RS40	Adjustable for all ports (default setting: port 1.4)
OCTOPUS	Adjustable for all ports (default setting: port 1.4)
MICE	Adjustable for all ports (default setting: port 1.4)
Power MICE	Adjustable for all ports (default setting: port 1.4)
MS20	Adjustable for all ports (default setting: port 1.4)
MS30	Adjustable for all ports (default setting: port 2.4)
RSR20/30	Adjustable for all ports (default setting: port 1.4)
MACH 100	Adjustable for all ports (default setting: port 2.4)
MACH 1000	Adjustable for all ports (default setting: port 1.4)
MACH 3000	Adjustable for all ports
MACH 4000	Adjustable for all ports (default setting: port 1.4)

Table 8: Port assignment for the redundant coupling (two-Switch coupling)

Note: Configure the coupling port and the redundancy ring ports on different ports.

- ☐ Activate the function in the “Operation” frame (see fig. 16).
- ☐ You now connect the redundant line.

The displays in the “Select port” frame mean (see fig. 16):

- “Port mode”: The port is either active or in stand-by mode.
- “Port state”: The port is either connected or not connected.
- “IP Address”: The IP address of the partner, if the partner is already operating in the network.

The displays in the “Information” frame mean (see fig. 23):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

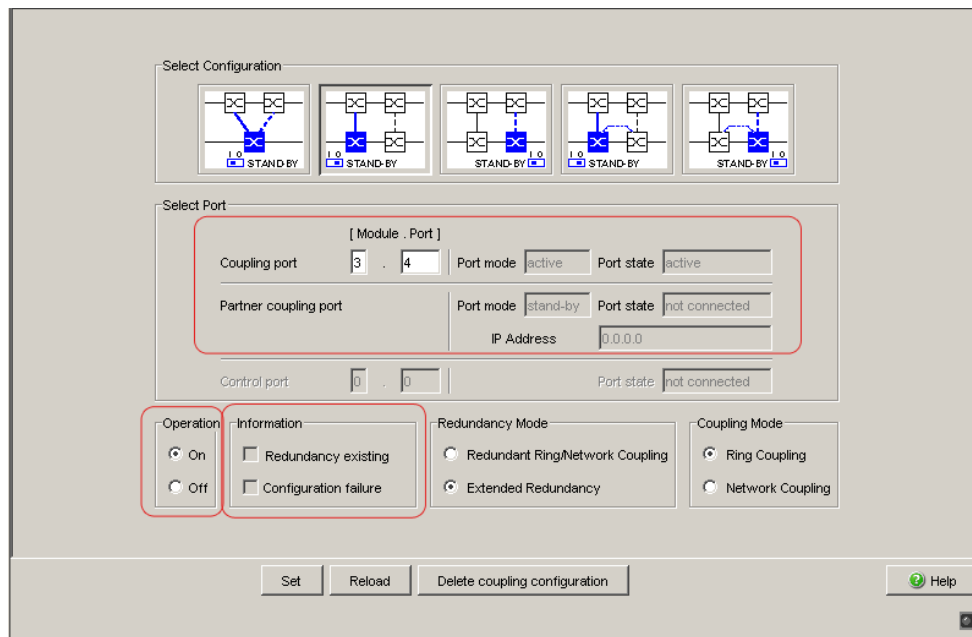


Figure 16: Selecting the port and enabling/disabling operation

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:

- switch off operation or
- change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

- Port: on
- Automatic configuration (autonegotiation):
on for twisted-pair connections
- Manual configuration: 100 Mbit/s FDX
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership U in the static VLAN table.

Note: If you are operating the Ring Manager and two-Switch coupling functions at the same time, there is the risk of creating a loop.

- ☐ Select two-Switch redundant coupling (see fig. 18).

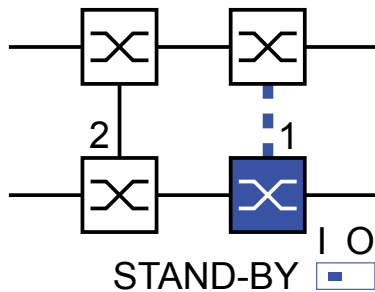


Figure 17: Two-Switch coupling

1: Coupling port

2: Partner coupling port

The following settings apply to the Switch displayed in blue in the selected graphic.

- ☐ Select the coupling port (see fig. 16), (see table 7).
With “Coupling port” you specify at which port you are connecting the network segments.
- ☐ If the STANDBY DIP switch is ON, connect the main line to the coupling port.

Note: Configure the coupling port and the redundancy ring ports on different ports.

- ☐ Activate the function in the “Operation” frame (see fig. 16).

The displays in the “Select port” frame mean (see fig. 16):

- “Port mode”: The port is either active or in stand-by mode.
- “Port state”: The port is either connected or not connected.
- “IP Address”: The IP address of the partner, if the partner is already operating in the network.

The displays in the “Information” frame mean (see fig. 16):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:

- switch off operation or
- change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

- Port: on
- Automatic configuration (autonegotiation):
on for twisted-pair connections
- Manual configuration: 100 Mbit/s FDX
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership \cup in the static VLAN table.

Note: If you are operating the Ring Manager and two-Switch coupling functions at the same time, there is the risk of creating a loop.

Redundancy mode

- ☐ In the “Redundancy Mode” frame, select (see fig. 18)
 - “Redundant Ring/Network Coupling” or
 - “Extended Redundancy”.

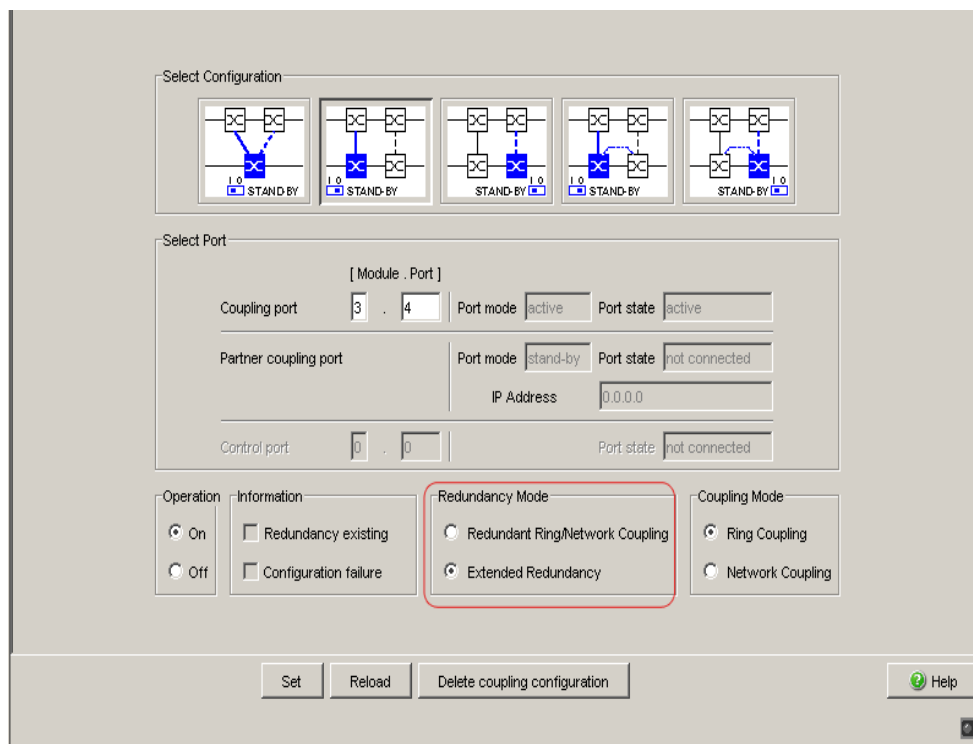


Figure 18: Selecting the redundancy mode

With the “Redundant Ring/Network Coupling” setting, either the main line or the redundant line is active. Both lines are never active simultaneously.

With the “Extended Redundancy” setting, the main line and the redundant line are simultaneously active if the connection line between the devices in the connected network fails (see fig. 12).

During the reconfiguration period, there may be package duplications. Therefore, only select this setting if your application detects package duplications.

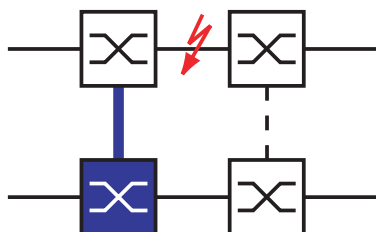


Figure 19: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

- ☐ In the “Coupling Mode” frame, select (see fig. 20)
 - “Ring Coupling” or
 - “Network Coupling”

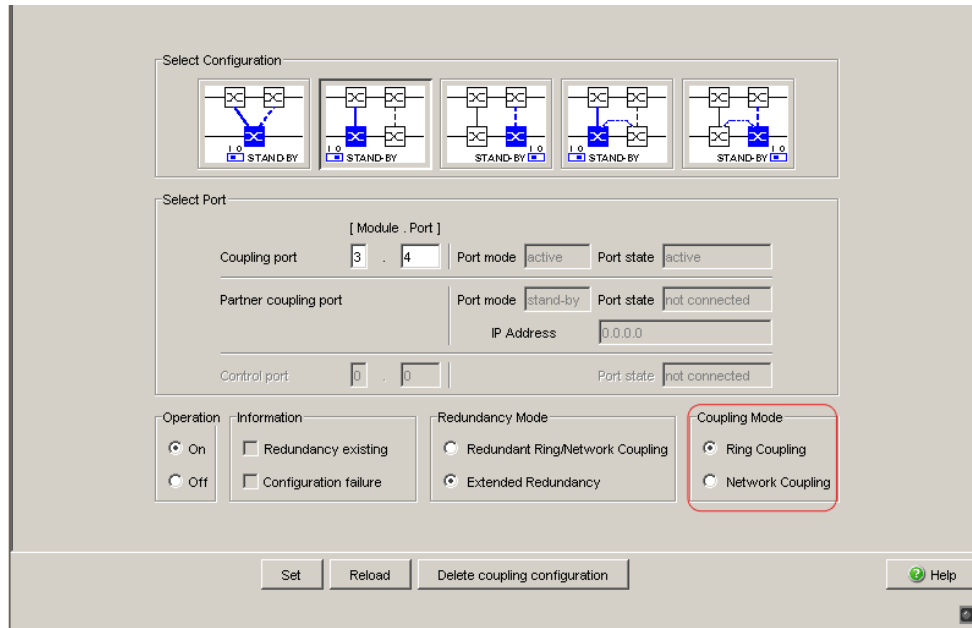


Figure 20: Selecting the coupling mode

- ☐ Select “**Ring coupling**” if you are connecting a redundancy ring.
- ☐ Select “**Network Coupling**” if you are connecting a line structure.

Delete coupling configuration

- ☐ The “Delete coupling configuration” button in the dialog allows you to reset all the coupling settings of the device to the state on delivery.

3.2.4 Two-Switch coupling with control line

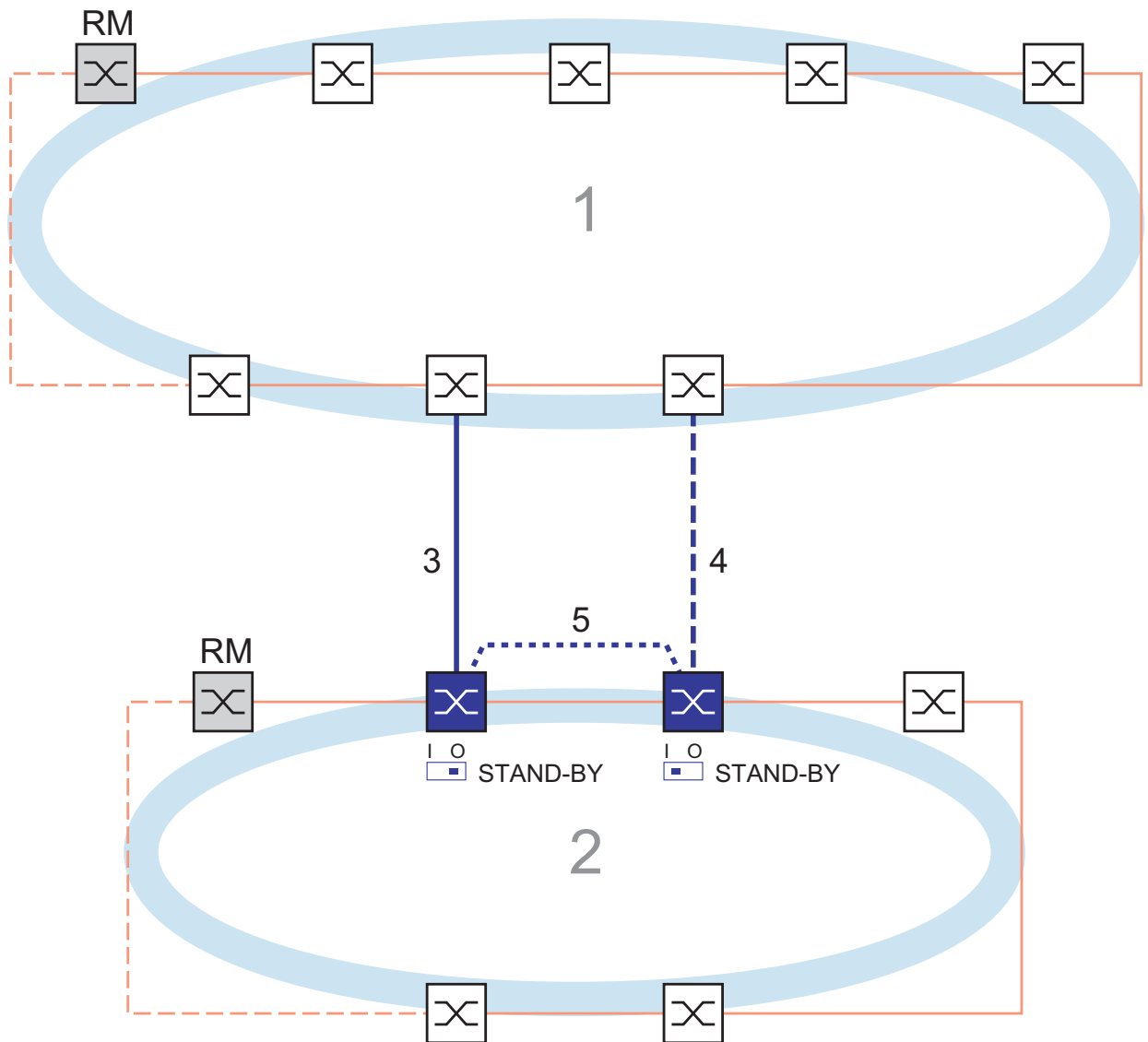


Figure 21: Example of Two-Switch coupling with control line

- 1: Backbone
- 2: Ring
- 3: Main line
- 4: Redundant line
- 5: Control line

The coupling between two networks is effected by the main line (thick blue line). If the main line fails, the redundant line (thick blue dotted line) takes over coupling the two networks.

The coupling is effected by two Switches.

The Switches send their control packets via a control line.

The device to which you connect the main line, and the device to which you connect the redundant line, are partners as regards the coupling.

☐ Connect the two partners via their ring ports.

☐ Select the Redundancy:Ring/Network Coupling dialog.

☐ Select two-Switch main coupling with control line (see fig. 22).

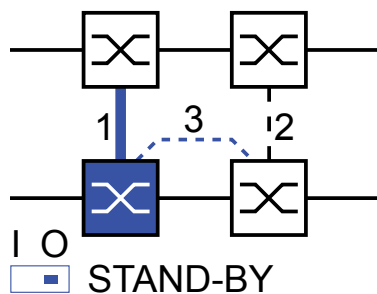


Figure 22: Two-Switch coupling with control line

1: Coupling port

2: Partner coupling port

3: Control line

The following settings apply to the Switch displayed in blue in the selected graphic.

☐ Select the coupling port (see fig. 23), (see table 9).

With “Coupling port” you specify at which port you are connecting the redundant line.

☐ If the STANDBY DIP switch is OFF, connect the main line to the coupling port.

☐ Select the control port (see fig. 23), (see table 9).

With “Control port” you specify at which port you are connecting the control line.

Device	Coupling port	Control port
RS2-./.	Port 1	Stand-by port (can only be combined with RS2-../..)
RS2-16M	Adjustable for all ports (default setting: port 1)	Adjustable for all ports (default setting: port 2)
RS20, RS30, RS40	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
OCTOPUS	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MICE	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
Power MICE	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MS20	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MS30	Adjustable for all ports (default setting: port 2.4)	Adjustable for all ports (default setting: port 2.3)
RSR20/RSR30	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MACH 100	Adjustable for all ports (default setting: port 2.4)	Adjustable for all ports (default setting: port 2.3)
MACH 1000	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)
MACH 3000	Adjustable for all ports	Adjustable for all ports
MACH 4000	Adjustable for all ports (default setting: port 1.4)	Adjustable for all ports (default setting: port 1.3)

Table 9: Port assignment for the redundant coupling (two-Switch coupling with control line)

Note: Configure the coupling port and the redundancy ring ports on different ports.

- ☐ Activate the function in the “Operation” frame (see fig. 16).
 - ☐ You now connect the redundant line and the control line.
- The displays in the “Select port” frame mean (see fig. 23):
- “Port mode”: The port is either active or in stand-by mode.
 - “Port state”: The port is either connected or not connected.
 - “IP Address”: The IP address of the partner, if the partner is already operating in the network.

The displays in the “Information” frame mean (see fig. 23):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

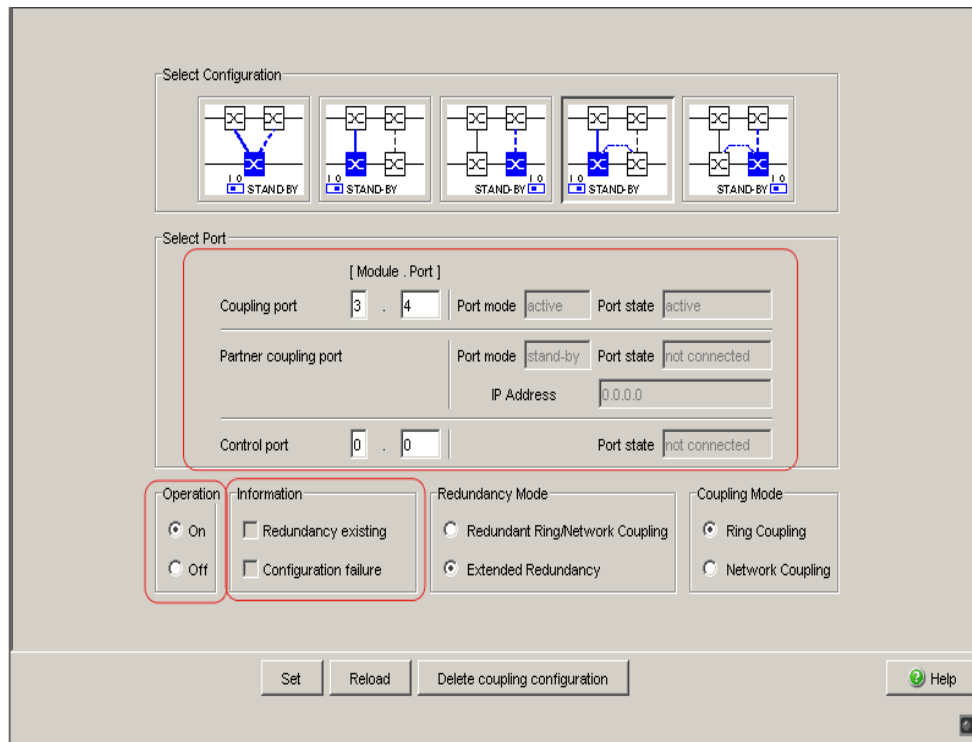


Figure 23: Selecting the port and enabling/disabling operation

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:

- switch off operation or
- change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

- Port: on
- Automatic configuration (autonegotiation):
on for twisted-pair connections
- Manual configuration: 100 Mbit/s FDX
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership \cup in the static VLAN table.

- ☐ Select two-Switch redundant coupling with control line (see fig. 24).

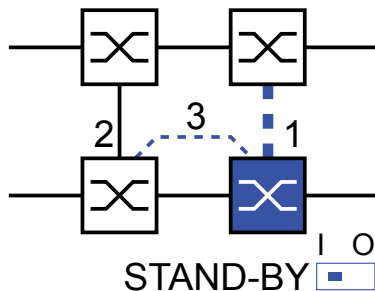


Figure 24: Two-Switch coupling with control line

1: Coupling port

2: Partner coupling port

3: Control line

The following settings apply to the Switch displayed in blue in the selected graphic.

- ☐ Select the coupling port (see fig. 23), (see table 9).
With “Coupling port” you specify at which port you are connecting the network segments.
- ☐ If the STANDBY DIP switch is ON, connect the main line to the coupling port.
- ☐ Select the control port (see fig. 23), (see table 9).
With “Control port” you specify at which port you are connecting the control line.

Note: Configure the coupling port and the redundancy ring ports on different ports.

- ☐ Activate the function in the “Operation” frame (see fig. 16).
- ☐ You now connect the redundant line and the control line.

The displays in the “Select port” frame mean (see fig. 23):

- “Port mode”: The port is either active or in stand-by mode.
- “Port state”: The port is either connected or not connected.
- “IP Address”: The IP address of the partner, if the partner is already operating in the network.

The displays in the “Information” frame mean (see fig. 23):

- “Redundancy existing”: One of the lines affected can fail, as a redundant line will then take over the function of the failed line.
- “Configuration failure”: The function is incomplete or incorrectly configured.

To avoid continuous loops, the Switch sets the port state of the coupling port to “off” if you:

- switch off operation or
- change the configuration

while the connections are in operation at these ports.

Note: The following settings are required for the coupling ports (you select the `Basic Settings:Port Configuration` dialog):

- Port: on
- Automatic configuration (autonegotiation):
on for twisted-pair connections
- Manual configuration: 100 Mbit/s FDX
for glass fiber connections

Note: If VLANs are configured, note the VLAN configuration of the coupling and partner coupling ports.

In the Network/Ring Coupling configuration, select for the coupling and partner coupling ports

- VLAN ID 1 and “Ingress Filtering” disabled in the port table and
- VLAN membership \cup in the static VLAN table.

Redundancy mode

- ☐ In the “Redundancy Mode” frame, select (see fig. 25)
 - “Redundant Ring/Network Coupling” or
 - “Extended Redundancy”.

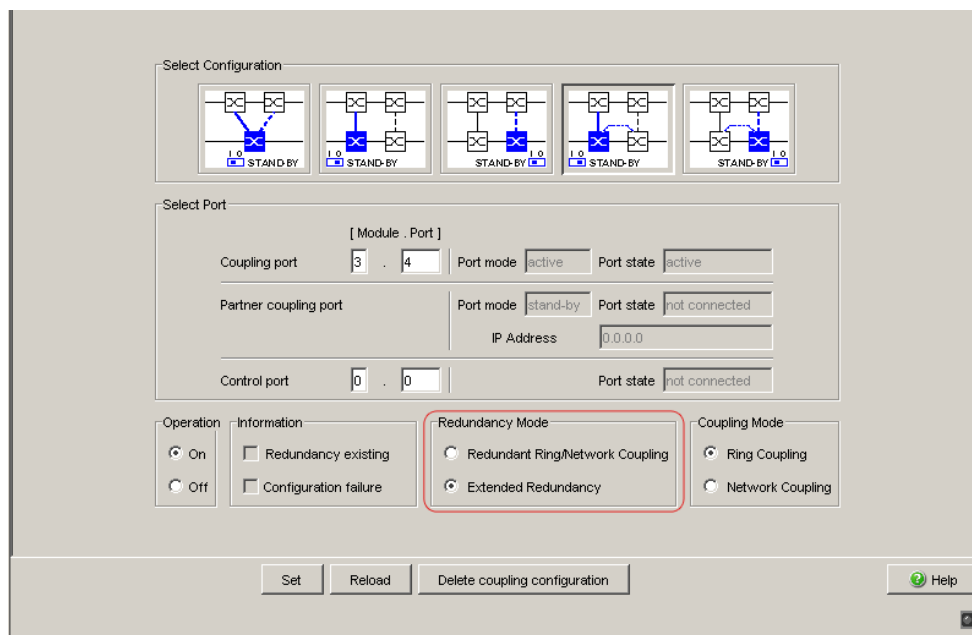


Figure 25: Selecting the redundancy mode

With the “Redundant Ring/Network Coupling” setting, either the main line or the redundant line is active. Both lines are never active simultaneously.

With the “Extended Redundancy” setting, the main line and the redundant line are simultaneously active if the connection line between the devices in the connected network fails (see fig. 12).

During the reconfiguration period, there may be package duplications. Therefore, only select this setting if your application detects package duplications.

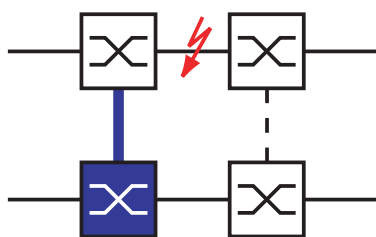


Figure 26: Extended redundancy

Coupling mode

The coupling mode indicates the type of the connected network.

- ☐ In the “Coupling Mode” frame, select (see fig. 27)
 - “Ring Coupling” or
 - “Network Coupling”

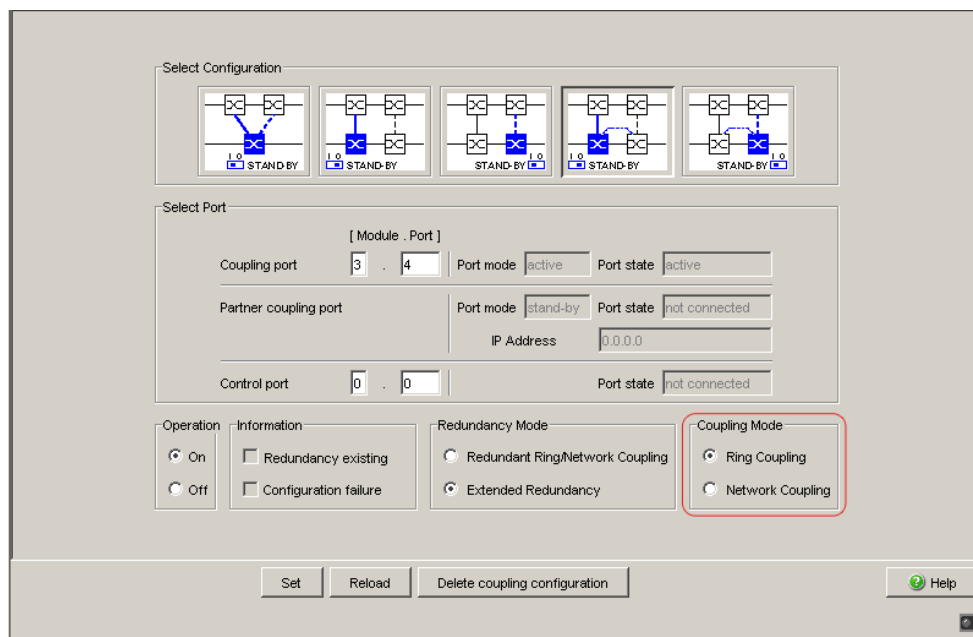


Figure 27: Selecting the coupling mode

- ☐ Select **“Ring coupling”** if you are connecting a redundancy ring.
- ☐ Select **“Network Coupling”** if you are connecting a line structure.

Delete coupling configuration

- ☐ The “Delete coupling configuration” button in the dialog allows you to reset all the coupling settings of the device to the state on delivery.

4 Rapid Spanning Tree

Note: The Spanning Tree and Rapid Spanning Tree protocols based on IEEE 802.1D-2004 and IEEE 802.1w respectively are protocols for MAC bridges. For this reason, the following description of these protocols usually employs the term bridge instead of switch.

Local networks are getting bigger and bigger. This applies to both the geographical expansion and the number of network participants. Therefore, it usually makes sense to use multiple bridges, for example:

- ▶ to reduce the network load in sub-areas,
- ▶ to set up redundant connections and
- ▶ to overcome distance limitations.

However, using multiple bridges with multiple redundant connections between the subnetworks can lead to loops and thus the total failure of the network. To prevent this, the (Rapid) Spanning Tree Algorithm was developed. The Rapid Spanning Tree Protocol (RSTP) enables redundancy by interrupting loops.

RSTP is a further development of the Spanning Tree Protocol (STP) and is compatible with it. If a connection or a bridge fails, the STP requires a maximum of 30 seconds to reconfigure. This was no longer acceptable in time-sensitive applications. The STP was therefore developed to the RSTP, leading to average reconfiguration times of less than a second. If you use RSTP in a ring topology with 10 - 20 devices, you can achieve reconfiguration times in the range of milliseconds.

Note: RSTP resolves a given topology to a tree structure (Spanning Tree). The number of devices in a branch (from the root to the branch tip) is limited by the parameter Max Age. The default value for Max Age is 20, it can be increased to 40.

You should note the following here: If the root device fails and another device takes over the root function, the largest possible number of devices decreases accordingly.

When network segments are connected to a MRP ring and you enable MRP compatibility, a peculiarity results. If the root bridge is located inside the MRP ring, the devices inside the MRP ring are combined into one virtual device for the purpose of calculating the branch length.

Note: The RSTP Standard dictates that all the devices within a network work with the (Rapid) Spanning Tree Algorithm. However, if STP and RSTP are used at the same time, the advantages of faster reconfiguration with RSTP are lost. RSTP devices also work in a limited MSTP environment within the scope of their functionality.

Note: Due to a change in the IEEE 802.1D-2004 standard on which RSTP is based, the Standards Commission has reduced the maximum value for the “Hello Time” from 10 to 2. When earlier firmware versions are upgraded to version 5.x or higher, the firmware automatically changes a locally entered “Hello Time” value greater than 2 to 2.

If the device is not the RSTP root, “Hello Time” values greater than 2 can remain valid, depending on the firmware version of the root device.

4.1 The Spanning Tree Protocol

Because RSTP is a further development of the STP, all the following descriptions of the STP also apply to the RSTP.

4.1.1 The tasks of the STP

The Spanning Tree Algorithm reduces network topologies that are set up using bridges, and that have ring structures with redundant connections, to a tree structure. In doing this, STP divides up the ring structures on the basis of specified rules by deactivating redundant paths. If a path is interrupted by mistake, the STP reactivates the path just deactivated. This enables redundant connections for increased data safety.

In forming the tree structure, the STP determines what is known as a root bridge. This forms the basis of the STP tree structure.

Features of the STP algorithm:

- ▶ automatic reconfiguration of the tree structure in the case of a bridge error or the interruption of a data path
- ▶ the tree structure is stabilized up to the maximum network size (up to 39 hops, depending on the setting for “Max. Age”)
- ▶ stabilization is effected within a brief, specified period
- ▶ topology can be specified and reproduced by the administrator
- ▶ transparency for the terminal devices
- ▶ low network load relative to the available transmission capacity due to the tree structure created

4.1.2 Bridge parameters

Each bridge is uniquely described using parameters:

- ▶ Bridge Identifier
- ▶ Root Path Costs for the bridge ports
- ▶ Port Identifier

4.1.3 Bridge Identifier

The Bridge Identifier consists of 8 bytes. The two highest-value bytes are the priority. The default setting for the priority number is 32,768, but the Management Administrator can change this when configuring the network. The six lowest-value bytes of the bridge identifier are the MAC address of the bridge. The MAC address guarantees that every bridge has a different bridge identifier.

The bridge with the smallest number for the bridge identifier has the highest priority.

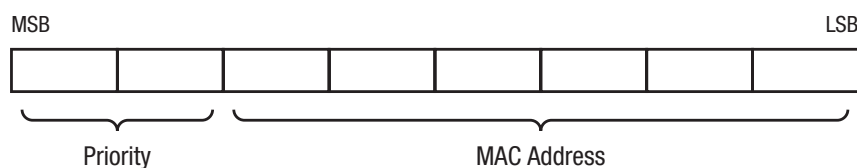


Figure 28: Bridge Identifier

4.1.4 Root Path Costs

Every path that connects two bridges is assigned costs for the transmission (path costs). The Switch specifies this value based on the transmission speed ([see table 10](#)). It assigns the higher path costs to paths with lower transmission speeds.

Alternatively, the Administrator can specify the path costs. Like the Switch, the Administrator assigns the higher path costs to paths with lower transmission speeds. However, since the Administrator can choose this value freely, he has a tool with which he can give a certain path an advantage among redundant paths.

The root path costs are the sum of all the individual path costs for all paths along which a data packet travels between the connected port of a bridge and the root bridge.

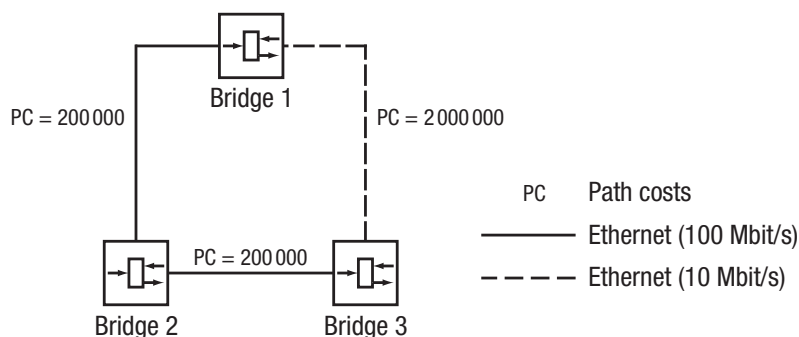


Figure 29: Path costs

Data rate	Recommended value	Recommended range	Possible range
<=100 KBit/s	200.000.000*	20.000.000-200.000.000	1-200.000.000
1 MBit/s	20.000.000*	2.000.000-200.000.000	1-200.000.000
10 MBit/s	2.000.000*	200.000-20.000.000	1-200.000.000
100 MBit/s	200.000*	20.000-2.000.000	1-200.000.000
1 GBit/s	20.000	2.000-200.000	1-200.000.000

Table 10: Recommended path costs for RSTP based on the data rate

* Bridges that conform with IEEE 802.1D, 1998 edition, and only support 16-bit values for the path costs should use the value 65 535 for path costs when they are used in conjunction with bridges that support 32-bit values for the path costs.

10 GBit/s	2.000	200-20.000	1-200.000.000
100 GBit/s	200	20-2.000	1-200.000.000
1 TBit/s	20	2-200	1-200.000.000
10 TBit/s	2	1-20	1-200.000.000

4.1.5 Port Identifier

The Port Identifier consists of 2 bytes. One part, the lowest-value byte, signifies the fixed relationship with the physical port number. This part ensures that no port of a bridge has the same identifier as another port of this bridge. The second part is the port priority, which is specified by the Administrator (default value: 128). It also applies here that the port with the smallest number for the port identifier has the highest priority.

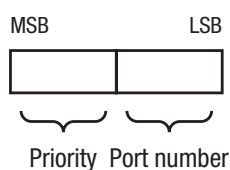


Figure 30: Port Identifier

4.2 Rules for creating the tree structure

4.2.1 Bridge information

To calculate the tree structure, the bridges require more detailed information about the other bridges located in the network.

To obtain this information, each bridge sends a BPDU (Bridge Protocol Data Unit) to the other bridges.

The contents of a BPDU include

- ▶ bridge identifier,
- ▶ root path costs and
- ▶ port identifier

(see IEEE 802.1D).

4.2.2 Setting up the tree structure

- ▶ The bridge with the smallest number for the bridge identifier is the root bridge. It is the root of the tree structure.
- ▶ The structure of the tree depends on the root path costs. STP selects the structure so that the path costs between each individual bridge and the root bridge are kept to a minimum.
- ▶ In the case of a number of paths with the same root path costs, the priority of the bridge identifier for the bridge connected to one of these paths decides which bridge should block.

- If two paths with the same root path costs lead out from a bridge, the port identifier is used as the last criterion (see fig. 30). This decides which port is selected.

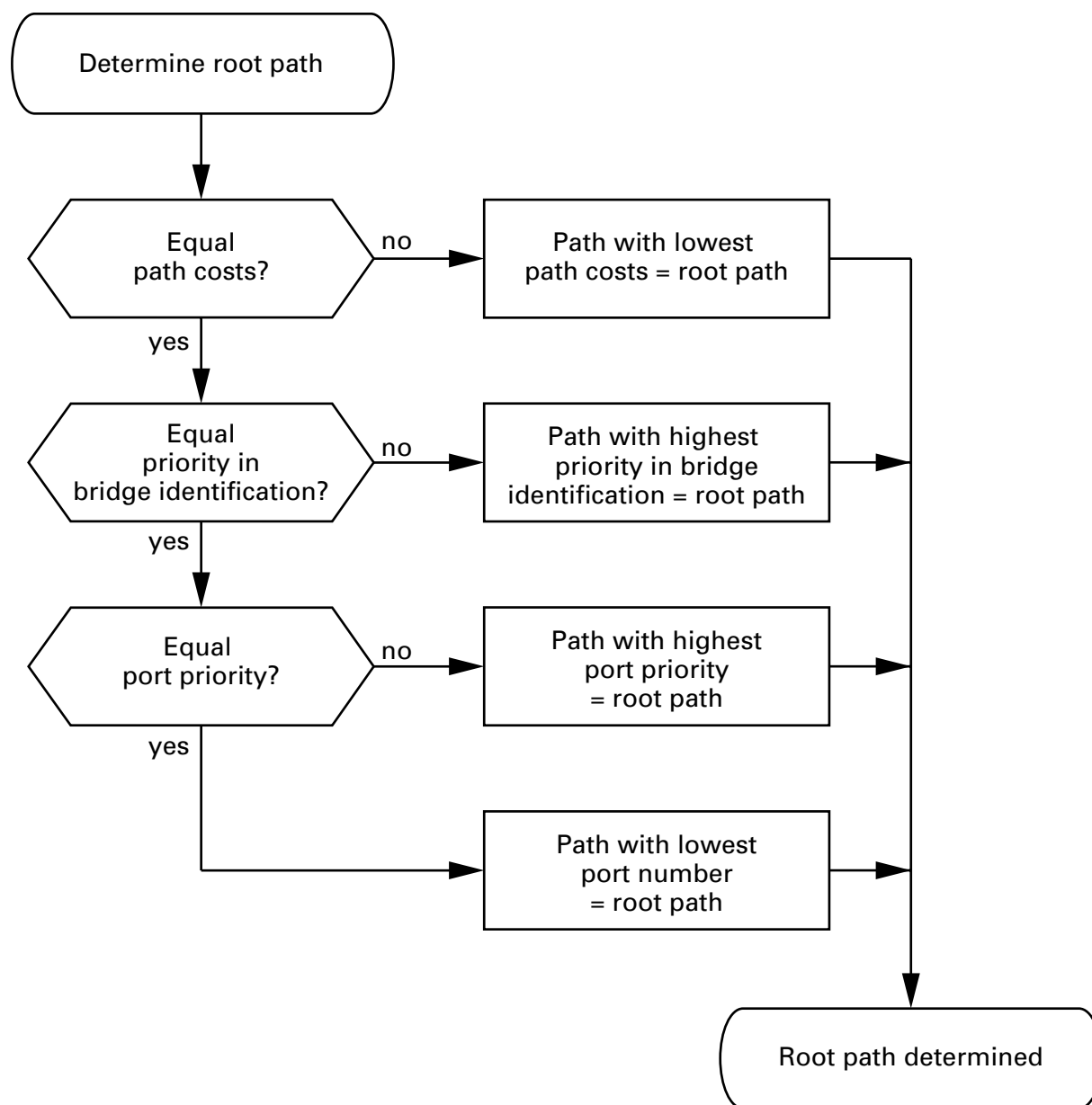


Figure 31: Flow diagram for specifying the root path

4.3 Example of specifying the root paths

The network plan (see fig. 32) can be used to create the flow diagram (see fig. 31) for defining the root path. The Administrator defined a different priority in the bridge identifier for each bridge. The bridge with the smallest number for the bridge identifier is the root bridge, in this case bridge 1. In the example, all the sub-paths have the same path costs. The path between bridge 2 and bridge 3 is interrupted, because a connection from bridge 3 to the root bridge via bridge 2 would double the path costs.

The path from bridge 6 to the root bridge is interesting:

- ▶ The path via bridge 5 and bridge 3 creates the same root path costs as the path via bridge 4 and bridge 2.
- ▶ The path via bridge 4 is selected because value 28 672 for the priority in the bridge identifier is smaller than value 32 768.
- ▶ However, there are two paths between bridge 6 and bridge 4. The port identifier is decisive here.

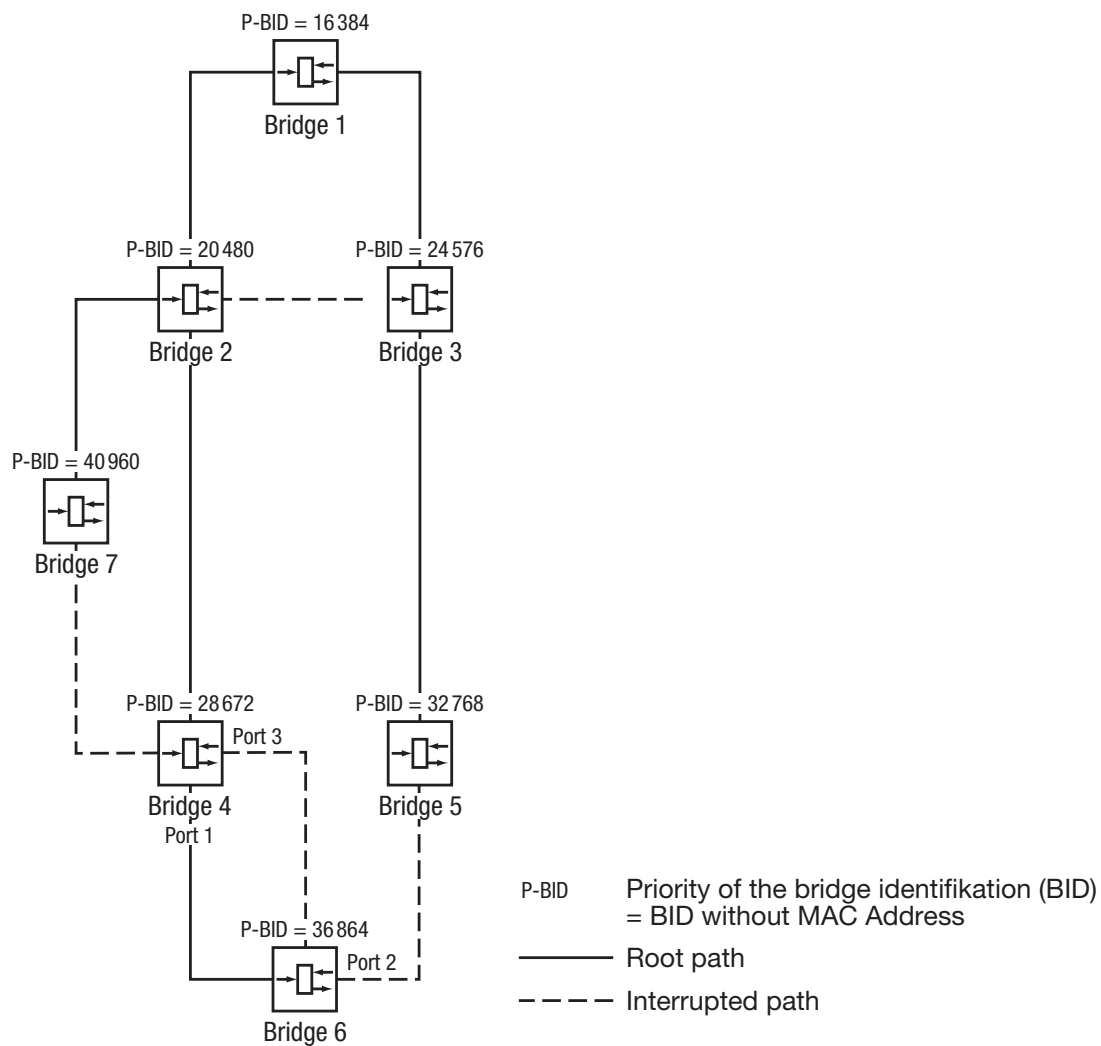


Figure 32: Example of specifying the root path

4.4 Example of manipulating the root paths

The network plan (see fig. 32) can be used to create the flow diagram (see fig. 31) for defining the root path. The Administrator

- left the default value of 32 768 for each bridge apart from bridge 1, and
- gave bridge 1 the value 16 384, thus making it the root bridge.

In the example, all the sub-paths have the same path costs. The path between bridge 2 and bridge 3 is interrupted, because a connection from bridge 3 to the root bridge via bridge 2 would double the path costs.

The path from bridge 6 to the root bridge is interesting:

- ▶ The path via bridge 5 and bridge 3 creates the same root path costs as the path via bridge 4 and bridge 2.
- ▶ STP selects the path using the bridge that has the lowest MAC address in the bridge identification (bridge 4 in the illustration).
- ▶ However, there are two paths between bridge 6 and bridge 4. The port identifier is decisive here.

Note: Because the Administrator does not change the default values for the priorities of the bridges in the bridge identifier, apart from the value for the root bridge, the MAC address in the bridge identifier alone determines which bridge becomes the new root bridge if the root bridge goes down.



4.5 Example of manipulating the tree structure

The Management Administrator soon discovers that this configuration with bridge 1 as the root bridge (see on page 61 „Example of specifying the root paths“) is unfavorable. On the paths from bridge 1 to bridge 2 and bridge 1 to bridge 3, the control packets which the root bridge sends to all other bridges are adding up.

If the Management Administrator makes bridge 2 the root bridge, the burden of the control packets on the subnetworks is distributed much more evenly. The result is the configuration shown here (see fig. 34). The distances between the individual bridges and the root bridge are now shorter.

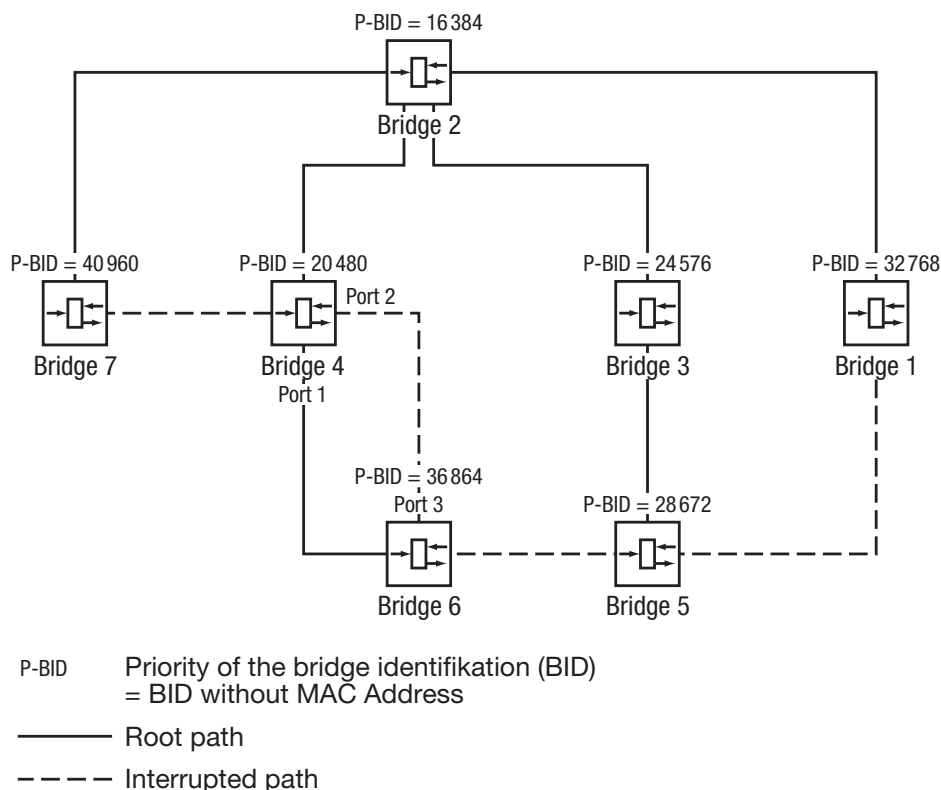


Figure 34: Example of manipulating the tree structure

4.6 The Rapid Spanning Tree Protocol

The RSTP takes over the calculation of the tree structure by the STP unchanged. RSTP merely changes parameters, and adds new parameters and mechanism that speed up the reconfiguration in the case of a failure. The ports play a significant role in this context.

4.6.1 Port roles

RSTP assigns each bridge port one of the following roles ([see fig. 35](#)):

- ▶ **Root port**
This is the port at which a bridge receives data packets with the lowest path costs from the root bridge.
If there are multiple ports with the same low path costs, the bridge identifier determines which port is the root port.
If there are multiple ports with the same low path costs and the same bridge identifier, the port identifier determines which port is the root port ([see fig. 31](#)).
The root bridge does not have a root port.
- ▶ **Designated port**
The bridge in a network segment that has the lowest root path costs is the designated bridge. If multiple bridges have the same root path costs, then the bridge with the smallest value for the bridge identifier becomes the designated bridge. The port on this bridge that connects it to a network segment that leads from the root bridge, is the designated port.
- ▶ **Edge port**
Every network segment in which there are no additional RSTP bridges is connected with exactly one designated port. This designated port is then also an edge port. The distinction of an edge port is the fact that it does not receive any RST BPDUs (Rapid Spanning Tree Bridge Protocol Data Unit).

- **Alternate port**
This is a blocked port that takes over the task of the bridge port if the connection to the root bridge fails. The alternate port guarantees the connection of the bridge to the root bridge.
- **Backup port**
This is a blocked port that serves as a backup in case the connection to the designated port of this network segment (without RSTP bridge) fails.
- **Disabled port**
This is the port that does not play any role with the Spanning Tree Operation, and is therefore switched off or does not have any connection.

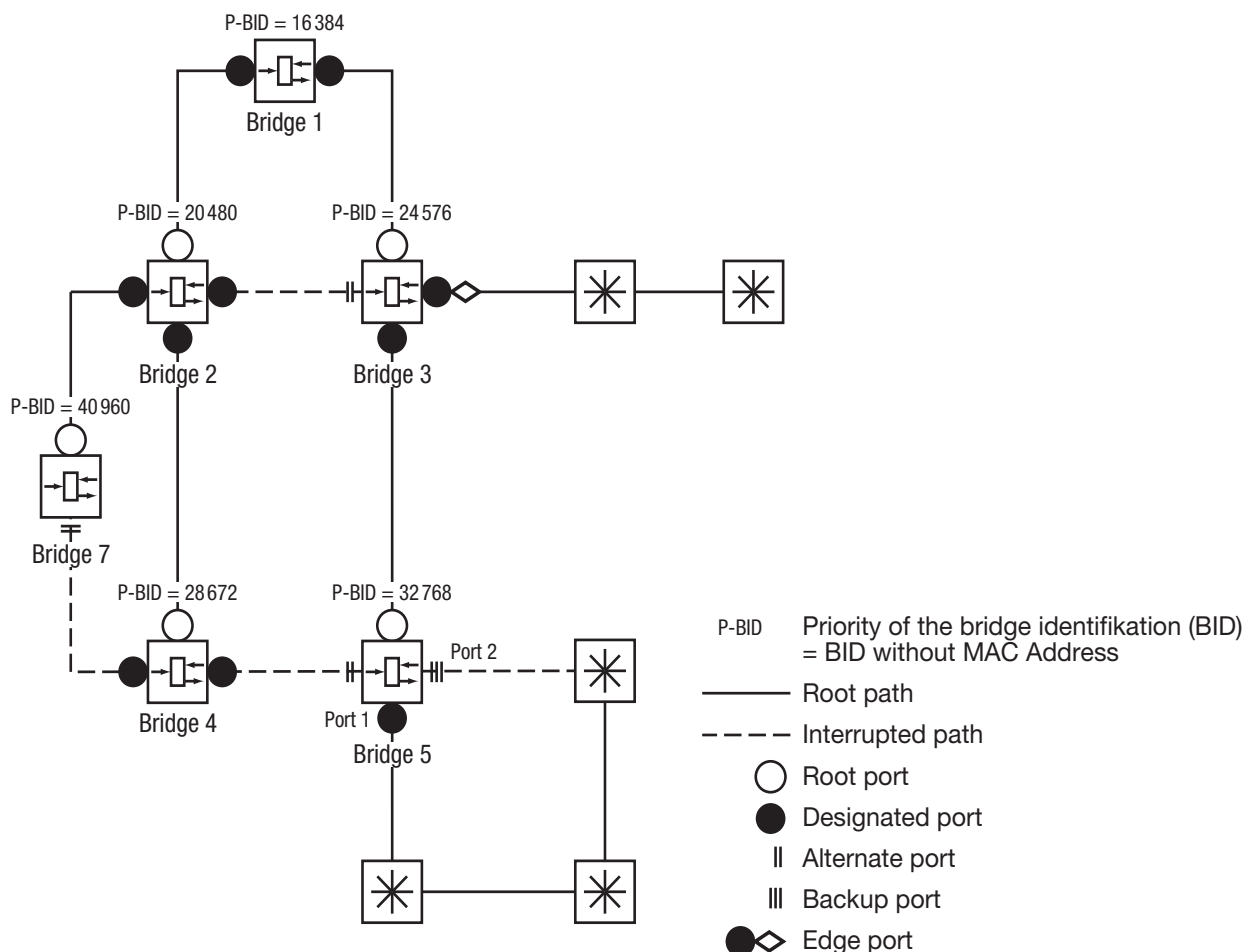


Figure 35: Port role assignment

4.6.2 Port states

Depending on the tree structure and the state of the selected connection paths, the RSTP assigns the ports their states.

STP port state	Administrative bridge port state	MAC operational	RSTP Port state	Active topology (port role)
DISABLED	Disabled	FALSE	Discarding*	Excluded (disabled)
DISABLED	Enabled	FALSE	Discarding*	Excluded (disabled)
BLOCKING	Enabled	TRUE	Discarding**	Excluded (alternate, backup)
LISTENING	Enabled	TRUE	Discarding**	Included (root, designated)
LEARNING	Enabled	TRUE	Learning	Included (root, designated)
FORWARDING	Enabled	TRUE	Forwarding	Included (root, designated)

Table 11: Relationship between port state values in STP and RSTP.

* the dot1d MIB shows "Disabled"

** the dot1d MIB shows "Blocked"

Meaning of the RSTP port states:

- ▶ Disabled = port does not belong to the active topology
- ▶ Discarding = no address learning in FDB and no data traffic apart from sending and receiving
- ▶ Learning = address learning active (FDB) and no data traffic apart from BPDUs
- ▶ Forwarding = address learning active (FDB) and sending and receiving active from all frames (not only BPDUs)

4.6.3 Spanning Tree Priority Vector

To assign roles to the ports, the RSTP bridges exchange configuration information with each other. This information is known as the Spanning Tree Priority Vector. It is part of the RST BPDUs and contains the following information:

- ▶ Bridge identifier of the root bridges
- ▶ Root path costs for the sending bridges
- ▶ Bridge identifier for the sending bridges
- ▶ Port identifiers of the ports through which the message was sent
- ▶ Port identifiers of the ports through which the message was received

Based on this information, the bridges participating in RSTP are able to calculate port roles themselves and define the port states of their own ports.

4.6.4 Fast reconfiguration

Why can RSTP react faster than STP to an interruption of the root path?

- ▶ Introduction of edge ports
During a reconfiguration, RSTP switches an edge port into the transmission mode after three seconds and then waits for the “Hello Time” (see [table 12](#)) to elapse, to be sure that no bridge sending BPDUs is connected.
When the user is sure that a terminal device is connected at this port and will remain connected, he can switch off RSTP at this port. Thus no waiting times occur at this port in the case of a reconfiguration.
- ▶ Introduction of alternate ports
As the port roles are already distributed in normal operation, a bridge can immediately switch from the root port to the alternate port after the connection to the root bridge is lost.
- ▶ Communication with neighboring bridges (point-to-point connections)
Decentralized, direct communication between neighboring bridges enables immediate reaction to status changes in the spanning tree architecture.
- ▶ Filter table
With STP, the age of the entries in the filter table determines the updating. RSTP immediately deletes the entries in those ports affected by a reconfiguration.
- ▶ Reaction to events
Without having to adhere to any time specifications, RSTP immediately reacts to events such as connection interruptions, connection reinstatements, etc.

Note: The price to be paid for this fast reconfiguration is the risk that data packets may be duplicated or mixed up during the reconfiguration phase. If this is unacceptable for your application, switch to the slower Spanning Tree Protocol or select one of the other, faster redundancy procedures described in this manual.

4.6.5 Configuring the Rapid Spanning Tree

- ☐ Set up the network to meet your requirements.

Note: Before you connect the redundant lines, you must complete the configuration of the RSTP.

You thus avoid loops during the configuration phase.



- ☐ Select the `Redundancy:Rapid Spanning Tree:Global` dialog.
- ☐ Switch on RSTP on every device

Operation

☒ On ☐ Off

Root Information

Priority / MAC Address

Root-Id: 20480 / 00:80:63:0f:1d:b0 ☐ This device is root

Root Port: 1

Root Cost: 220000

Protocol Configuration / Information

Priority: 32768 MAC Address: 00:80:63:51:82:80

Hello Time [s]: 2 Topology Changes: 1

Forward Delay [s]: 30 Time since last change: 0 day(s), 2:14:54

Max Age [s]: 6

Set Reload Help

Figure 36: Operation on/off

- ☐ You now connect the redundant lines.
- ☐ Define the desired Switch as the root Switch by assigning it the lowest priority in the bridge information among all the Switches in the network, in the “Protocol Configuration/Information” frame. Note that only multiples of 4096 can be entered for this value (see table 12). In the “Root Information” frame, the dialog shows this device as the root.
A root switch has no root port and no root costs.
- ☐ As required, you change the default priority value of 32768 in other Switches in the network in the same way to the value you want (multiple of 4096).
For each of these Switches, check the display in the “Root Information” frame:
 - Root-Id: Displays the bridge identifier of the root Switch
 - Root Port: Displays the port that leads to the root Switch
 - Root Cost: Displays the root costs to the root Switch
 in the “Protocol Configuration/Information” frame:
 - Priority: Displays the priority in the bridge identifier for this Switch
 - MAC Address: Displays the MAC address of this Switch
 - Topology Changes: Displays the number of changes since the start of RSTP
 - Time since last change: Displays the time that has elapsed since the last network reconfiguration

- If required, change the values for “Hello Time”, “Forward Delay” and “Max. Age” in the root Switch. The root Switch then transfers this data to the other Switches. The dialog displays the data received from the root Switch in the left column. In the right column you enter the values which shall apply when this Switch becomes a root Switch. For the configuration, take note of [table 12](#).

The screenshot shows a configuration window for RSTP. It has two main sections: 'Root Information' and 'Protocol Configuration / Information'. The 'Root Information' section includes fields for Root-Id (20480), Root Port (1.4), and Root Cost (220000), along with a checkbox for 'This device is root'. The 'Protocol Configuration / Information' section contains a table for timing parameters. A red box highlights the 'Hello Time [s]', 'Forward Delay [s]', and 'Max Age [s]' columns. The 'Hello Time' row shows 2 in the left column and 2 in the right column. The 'Forward Delay' row shows 30 in the left column and 15 in the right column. The 'Max Age' row shows 5 in the left column and 20 in the right column. Other fields include Priority (32768), MAC Address (00 80 63 51 82 80), Topology Changes (1), and Time since last change (0 day(s), 2:14:54). At the bottom are 'Set', 'Reload', and 'Help' buttons.

Root Information	
Root-Id	20480
Root Port	1.4
Root Cost	220000

Protocol Configuration / Information	
Priority	32768
MAC Address	00 80 63 51 82 80
Topology Changes	1
Time since last change	0 day(s), 2:14:54
Hello Time [s]	2
Forward Delay [s]	15
Max Age [s]	20

Figure 37: Assigning Hello Time, Forward Delay und Max. Age

The times entered in the RSTP dialog are in units of 1 s.
Example: Hello Time = 2 corresponds to 2 seconds.

Parameter	Meaning	Value range	Default setting
Priority	The priority and the MAC address go together to make up the bridge identification.	$0 < n \cdot 4,096 < 61,440$	32.768
Hello Time	The left column shows the value currently being used by the root bridge. The device periodically receives configuration frames (Hello frames) from the root bridge. The Hello Time shows the time between two successive configuration frames sent by the root bridge. If you configure the current device as the root bridge, the other devices in the entire network will assume the value in the right column.	1 - 2	2
Forward Delay	The left column shows the value currently being used by the root bridge. The predecessor protocol STP used the parameter to control (delay) the transition time between the states „disabled“, „blocking“, „learning“, „forwarding“. Since the introduction of RSTP, this parameter has only secondary relevance because state transitions are negotiated between RSTP bridges without a given time delay. If you configure the current device as the root bridge, the other devices in the entire network will assume the value in the right column.	4 - 30 (see a:)	30
Max Age	The left column shows the value currently being used by the root Switch. Contrary to the past (STP) meaning, Max Age now (for RSTP) denotes the maximum permissible branch length (number of devices to the root bridge). If you configure the current device as the root bridge, the other devices in the entire network will assume the value in the right column.	6 - 40 (see a:)	6

Table 12: Global RSTP settings

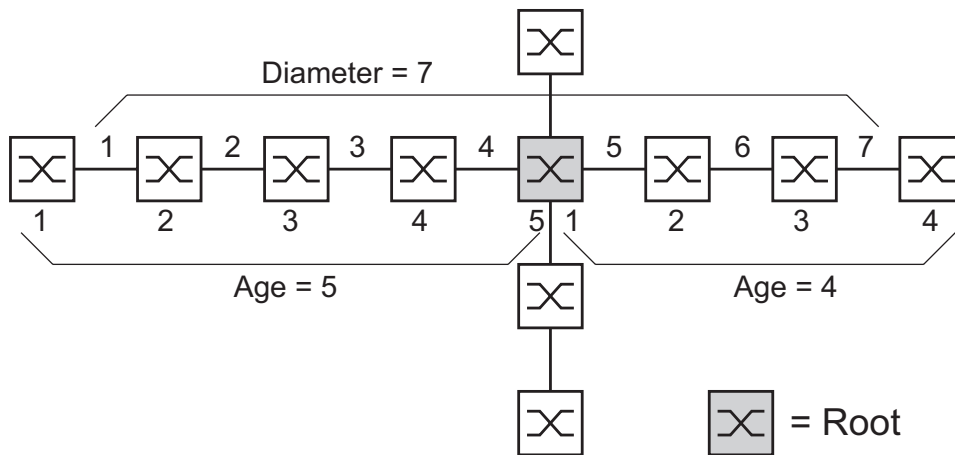


Figure 38: Definition of diameter and age

The diameter is the number of connections between the two devices furthest away from the root bridge.

The parameters

- Forward Delay and
- Max Age

have a relationship to each other:

Forward Delay $\geq (\text{Max Age}/2) + 1$

If you enter values that contradict this relationship, the device then replaces these values with a default value or with the last valid values.

- ☐ As required, change and verify the settings and displays that relate to each individual port (menu bar: Rapid Spanning Tree - Port).

Module	Port	STP State Enable	Port State	Priority	Port Pathcost	Admin EdgePort	Oper EdgePort	Auto EdgePort	Oper PointToPoint	Designated Root (Priority/MAC Address)
1	1	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	2	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	3	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	4	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	5	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	6	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	7	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	8	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	9	<input checked="" type="checkbox"/>	manualFwd	128	0	false	false	true	true	80 00 00 80 63 74 67
1	10	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	11	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	12	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	13	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	14	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	15	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	16	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	17	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	18	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	19	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	20	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	21	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67
1	22	<input checked="" type="checkbox"/>	disabled	128	0	false	false	true	false	80 00 00 80 63 74 67

Set
Reload
Help

Figure 39: Configuring the RSTP port

Note: Deactivate the Spanning Tree Protocol for the ports connected to a redundant ring, because the Spanning Tree and the Ring Redundancy work with different reaction times.

Parameter	Meaning	Value range	Default setting
STP State Enable	Here you can turn RSTP on or off for this port. If you turn RSTP off for this port while RSTP is globally enabled for the device, the device will discard RSTP frames received on this port.	on, off	on
Port State	Displays the port state	disabled, forwarding, discarding, blocking, learning	-
Priority	Here you enter the first byte of the port identification.	$16 < n \cdot 16 < 240$	128
Port Path Cost	Enter the path costs to indicate preference for redundant paths. If the value is "0", the Switch automatically calculates the path costs depending on the transmission rate.	0 - 200.000.000	0
Admin Edge Port	If the parameter is set to „true“, the port will transition to the forwarding state. If the port nevertheless receives a RSTP frame, it will transition to the blocking state and the bridge will then determine the new port role. .If the parameter's value is „false“, the port remains in the blocked state until the bridge has determined the port role. Only after that will the port transition to its final state.	true, false	false
Oper Edge Port	Is „true“ if no RSTP frames were received, i. e., a terminal device that sends no RSTP frames is connected to this port. Is „false“ if RSTP frames were received, i. e., no terminal device but a bridge is connected.	true, false	-
Auto Edge Port	The setting for Auto Edge Port only takes effect if the parameter Oper Edge Port has been set to „false“. if Auto Edge Port is set to „true“, the port will transition to the forwarding state within $1.5 \cdot \text{Hello Time}$ (3 seconds). If is is set to „false“, it will take 30 seconds until the edge port forwards data frames.	true, false	false

Table 13: Port-related RSTP settings and displays

Parameter	Meaning	Value range	Default setting
Oper Point-ToPoint	If this port has a full-duplex link to another RSTP device, the value for Oper PointToPoint will become „true“, else it will become „false“ (e. g., if a hub is connected). A Point-to-point connection is a direct connection between two RSTP devices. The direct, local communications between the two switches results in a short reconfiguration time.	true, false	auto (is calculated): FDX = true HDX = false
Designated Root	Displays the bridge identification of the designated root Switch for this port.	Bridge identification (hexadecimal)	-
Designated Costs	Display of the costs of the path from this port to the root Switch.	Costs	-
Designated Port	Display of the port identifier of the port that creates the connection to the root Switch for this port (on the designated Switch).	Port identification (hexadecimal) and port number	-

Table 13: Port-related RSTP settings and displays

4.7 Combination of RSTP and MRP

In the MRP compatibility mode, the device allows you to combine RSTP with MRP.

With the combination of RSTP and MRP, the fast switching times of MRP are maintained.

The RSTP diameter (see fig. 38) depends on the “Max Age”. It applies to the devices outside the MRP-Ring.

Note: The combination of RSTP and MRP requires the root bridge and the backup root bridge to be within the MRP-Ring.

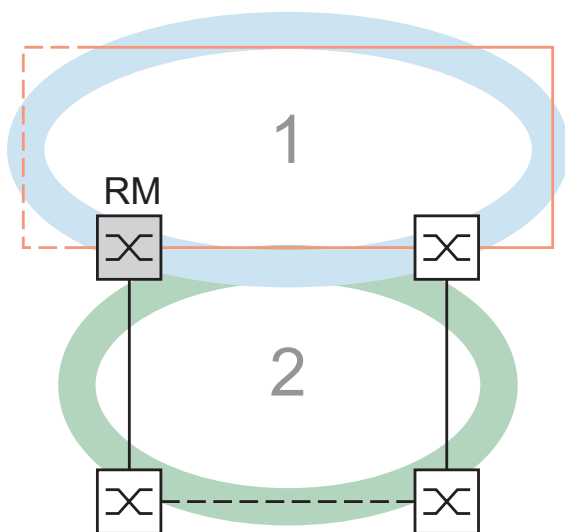


Figure 40: Combination of RSTP and MRP

1: MRP-Ring

2: RSTP-Ring

RM: Ring Manager

To combine RSTP with MRP, you perform the following steps in sequence:

- ▶ Configure MRP on all devices in the MRP-Ring.
- ▶ Activate RSTP at the RSTP ports and also at the MRP-Ring ports.
- ▶ Configure the RSTP root bridge and the RSTP backup root bridge in the MRP-Ring:
 - Set the priority.
 - If you exceed the RSTP diameter specified by the preset value of Max Age = 20, you modify “Max Age” and “Forward Delay”.
- ▶ Activate RSTP globally.
- ▶ Activate the MRP compatibility mode.
- ▶ After configuring all the participating devices, connect the redundant RSTP connection.

4.7.1 Application example for the combination of RSTP and MRP

The figure (see fig. 41) shows an example for the combination of RSTP and MRP.

Parameter	S1	S2	S3	S4
MRP settings				
Ring redundancy: MRP version	MRP	MRP		
Ring port 1	1.1	1.2		
Ring port 2	1.1	1.2		
Redundancy Manager mode	On	Off	–	–
MRP operation	On	On	Off	Off
RSTP settings				
For each RSTP port: STP State Enable	On	On	On	On
Protocol Configuration: Priority (S2<S1<S3 and S2<S1<S4)	4096	0	32768	32768
RSTP:Global: Operation	On	On	On	On
RSTP:Global: MRP compatibility	On	On	–	–

Prerequisites for further configuration:

- You have configured the MRP settings for the devices in accordance with the above table.

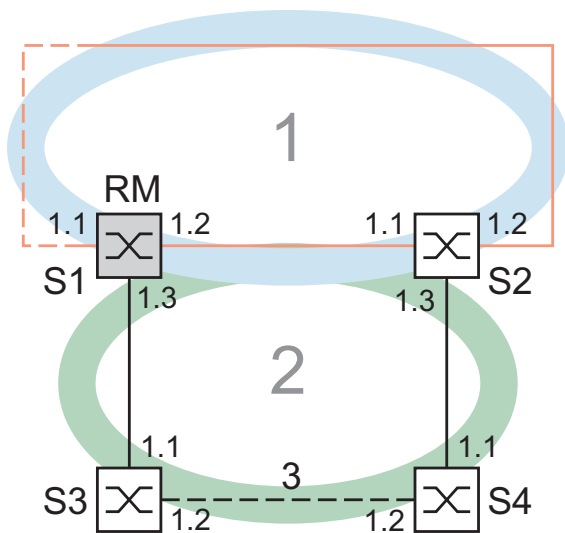


Figure 41: Application example for the combination of RSTP and MRP

1: MRP-Ring

2: RSTP-Ring

3: Redundant RSTP connection

RM: Ring Manager

- ☐ Activate RSTP at the ports here using S1 as an example.

<code>enable</code>	Switch to the Privileged EXEC mode.
<code>configure</code>	Switch to the Configuration mode.
<code>interface 1/1</code>	Switch to the Interface Configuration mode of interface 1/1.
<code>spanning-tree port mode</code>	Activate RSTP at port.
<code>exit</code>	Switch to the Configuration mode.
<code>interface 1/2</code>	Switch to the interface configuration mode for port 1.2.
<code>spanning-tree port mode</code>	Activate RSTP at port.
<code>exit</code>	Switch to the Configuration mode.
<code>interface 1/3</code>	Switch to the interface configuration mode for port 1.3.
<code>spanning-tree port mode</code>	Activate RSTP at port.
<code>exit</code>	Switch to the Configuration mode.

- ☐ Configure globally here using S1 as an example:
- the RSTP priority
 - global operation
 - the MRP compatibility mode

<code>spanning-tree mst priority 0 4096</code>	Set the RSTP priority to the value 4096.
<code>spanning-tree</code>	Activate RSTP operation globally.
<code>spanning-tree stp-mrp-mode</code>	Activate MRP compatibility.

- ☐ Configure all the participating devices in accordance with the table.
- ☐ Connect the redundant RSTP connection.

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What is your opinion of this manual? We are always striving to provide as comprehensive a description of our product as possible, as well as important information that will ensure trouble-free operation. Your comments and suggestions help us to further improve the quality of our documentation.

Your assessment of this manual:

	Very good	Good	Satisfactory	Medio- cre	Poor
Precise description	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Completeness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Graphics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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■ **Technical questions and training courses**

In the event of technical queries, please contact your local Hirschmann distributor or Hirschmann office.

You can find the addresses of our distributors on the Internet:

www.hirschmann-ac.com.

Our support line is also at your disposal:

- ▶ Tel. +49 1805 14-1538
- ▶ Fax +49 7127 14-1551

Answers to Frequently Asked Questions can be found on the Hirschmann internet site (www.hirschmann-ac.com) at the end of the product sites in the FAQ category.

The current training courses to technology and products can be found under <http://www.hicomcenter.com>.

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